SCHOOL SCIENCE AND MATHEMATICS

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SYMPOSIUM ON THE PURPOSE AND ORGANIZATION OF PHYSICS TEACHING IN SECONDARY SCHOOLS.

The following symposium on the subject of the purposes and organization of physics teaching was arranged by the National Commission on the Teaching of Physics as explained in SCHOOL SCIENCE AND MATHEMATICS for June, 1908, page 522. The contributions have been sent in in response to an invitation issued by the commission, and appear in the order in which they were received chronologically. Further contributions will appear in the next issue, and the entire series will be followed by an analysis of the content of the whole. Brief and pointed discussions of the articles in the syllabus will be welcome, and should be sent direct to the managing editor.

I. BY PRESIDENT NICHOLAS MURRAY BUTLER,

Columbia University, New York.

1. The topics chosen and the method pursued should be determined by the intellectual needs and interests of pupils of secondary school age. College admission tests in physics should be made to depend upon the secondary school teaching of that subject, when properly organized and conducted, and not vice versa.

2. The teacher should put out of his mind the thought that each pupil before him is aiming to become a specialist in physical science, or that the study of physics is his main interest in life.

Instead of following the logical order of topics as this would present itself to an expert physicist, he should follow the psychological order as this reveals itself in the natural working of an intelligent and curious mind of secondary school age.

3. Physical science should not be presented as something fixed and definite, whose conclusions are final, but rather as a division of organized knowledge which is constantly expanding and developing and which has frequently, within historic times, corrected its conclusions in the light of later discoveries. To this end some outline of the history of physical science and of the time and order in which its fundamental laws were discovered and developed should be given to the student. Wherever it is possible to relate the discovery or new application of a physical principle to man's other activities, this should be done in order that the student may be made to feel from the beginning the intimate relation between the laws and phenomena with which physics deals, and other human interests. In other words, the teaching of physics should be humanized.

4. As a farther step in the humanizing of physics teaching, the pupil should be brought to know something of the men whose names are epoch-marking in the history of physical science. Such names as those of Archimedes, Galileo, Newton, Kepler, Gauss, Young, Gay-Lussac, Davy, Faraday, Helmholtz, Kelvin, Torricelli, Ampére, Joule, Mayer, Fresnel, Galvani, Volta, should be familiar to the student, and he should be able to tell something of who these men were, when they lived, and what they did which causes them to be remembered in the history of science.

5. By material drawn from the third book of John Stuart Mill's Logic, or from Professor Jevons's Principles of Science, the student should be made to understand the significance of the inductive method, of the verification of hypothesis and of the formulation of so-called laws of nature.

6. The ordinary standards for measuring time, space, weight and other characteristics, should not be taken for granted, but their origin and history should be made plain and their fundamental principles discussed. Under this head I would include also the thermometer, the barometer, the microscope, the telescope, and the spectroscope.

7. It is difficult for one not himself a physicist to make any profitable suggestions as to the subjects to be selected for presentation to students of physics in secondary schools. In gen-

eral, however, it may safely be held that these subjects should be those general ones which relate in an elemental or fundamental way to matter and motion. The tendency observable in many school text-books to pursue these subjects into very refined and subtle inferences, is to be deprecated. Taught in this way the beginner loses his sense of perspective and physics repels rather than attracts him.

8. Far too much has been made in recent years of accuracy of measurement in the teaching of elementary physics. It is much more important to throw emphasis upon the descriptive aspects of the science and to feed the growing mind with food that really interests it and helps it to grow, than to pursue the will-o'-the wisp of training some imaginary power of habitual accuracy. Accurate measurements have their place in the teaching of elementary physics, but that place is a subordinate one. The main task is to teach the constitution and behavior of matter, as it presents itself to the human power of perception, and the laws of motion as these have been observed and deduced, together with the relation of these to man and his activities.

II. By Professor E. A. Strong,

State Normal School, Ypsilanti, Mich.

"What should be the aim of the course in physics?" I must confess to a cowardly impulse to shirk such general questions, as likely to begin in metaphysics and end in polemics. They remind me of that first question of the Shorter Catechism which used to be fired at us in Sunday School when I was a boy: "What is the chief end of man?" a question easy enough if only you know the answer, but otherwise something of a poser. Now let me frankly say that I happen to know the answer to the question that introduces this paragraph. I learned it along with the Shorter Catechism. *The aim of the instruction in physics is the general educational aim.* And if further questioned concerning this general educational aim, I think I could state it in terms of the satisfaction of human needs and desires, as revealed in law, language, literature, institutions, etc. But if asked why the satisfaction of human needs and desires is a good I should give it up. Or, one may push the inquiry the other way and inquire not for the ground of the aim but for the method of attaining it, and again the answer seems easy so long as it is kept in the

vague. Method will appear in the nature of the learner and of that which is to be learned, in physics and psychology. Put in orderly array what is known about the natural world on the one hand, and on the other hand the interests of the boy at various ages and the community interests of the time, and it should not be difficult for the expert to make and justify a course of study. Only we must always give to "interests" its double meaning, what *concerns* as well as what *appeals to* us.

Now such a discussion as that hinted at above is extremely familiar to us all, only it does not seem to lay hold on realities to any great extent. I myself prefer to hint, in stating the aim, at the possibility of putting more power into the work by bringing in motive, feeling, impulse, tendency, especially community and national, to bear upon the work. I would make physics *interesting* by drawing the material of instruction from the juvenile and the neighborhood occupations of the time and place. Knowledge comes through the exhibition of the material of instruction. Make the work interesting, while still conformable to the great educational aim, by the choice of fresh and interesting material of instruction. This is no mean aim: to lure to further study; to make every pupil say: "We will hear thee again of this matter."

But our professional literature is so flooded with clever generalizations which have a rich meaning only to those who are rich in experience that the sight is not infrequent of a teacher who goes about his work humming one or other of these formulas while walking counter to them all. And so it is necessary to translate any statement of the purpose of the physics instruction into some definite word suited to the hour. At least, I find it necessary to say to myself continually: "See to it that your pupils have a meaning, a valuable and appealing content in the mind, when they talk. And then see to it that they express that meaning with accuracy. The linguistic side of the instruction is not unimportant but fundamental. Science is social and so essentially a matter of expression. When a boy is "reciting" is he describing a concept that he has formed in a legitimate way by observation, or is he groping about for one of many half-remembered formulas, which having little meaning to him has also little power to compel him to express a meaning?

III. By Professor John F. Woodhull,
Teachers College, Columbia University, New York.

1. Physics for high schools should consist of a well-organized mass of useful information.

2. In order that the amount of information may be considerable it should be given for the most part "second hand."

3. The three means for giving this information, stating the more important first, are: (a) Illustrated lectures. (b) Study of text-book with recitations, and reading many references in books and magazines with written and oral reports. (c) Laboratory work, a small portion of which should consist of exact measurements.

4. If this organized mass of useful information is acquired at the hand of a competent teacher, it will involve discipline and training. There is no occasion for the statement that high school pupils of to-day more than in the past require entertainment and avoid work. Pupils of all ages have a right to ask that work required of them should appeal to their best judgment as worth their while.

5. While the physics teacher has a peculiar part to perform in the process of education which the teacher of no other subject can do so well, his task is not so absolutely unique as he has in some cases supposed, and the methods of instruction which are best in the treatment of other subjects are for the most part best for physics.

6. Nothing has so retarded the progress of physics teaching as the idea that it is essentially a science of measurements and that its chief function is to train pupils in accuracy by means of exact measurements. A quantitative treatment with whole numbers, so to speak, should run through much of the instruction in lectures, recitations and laboratory work, giving concreteness and therefore interest to the subject, but this is only incidental and of minor importance.

7. Physics should not be presented as a catalogue of principles, but rather as history, biography and the evolution of changing ideas. The topics for study should be phenomena rather than laws, and principles should be presented only for the purpose of explaining some definite problems in life.

8. Since all that has been said above applies equally to all general or first courses in physics whether given in high school or college, it follows that college admission tests should be the same as high school graduation tests.

IV. By Professor Henry Crew,

Northwestern University, Evanston, Ill.

When one who has spent his entire life in a single field of endeavor ventures to speak concerning proper motives and methods for those working in another field, he is quite liable to utter either platitudes or arrant nonsense. It is therefore with the double understanding that I have had no experience in secondary teaching and that my present task is not self-imposed, that I dare to express the following views concerning the purpose and principles of teaching physics in the high school.

The fundamental purpose of physical science in secondary instruction can, however, hardly be other than "training for power;" by which is meant that training which will enable the student to grow in the power of clear thought and vision, training which will cultivate in him a healthful respect for the essential facts of the case, and will lead him to respond reasonably and ethically to every circumstance which confronts him.

The considerations which persuade so many high school principals to introduce physics into the secondary curriculum are doubtless nearly, if not quite, the same as those which lead to a widely expressed preference, on the part of college authorities, for physics as an entrant science. When we confine our attention to the phenomena of matter, as distinguished from mind, it is evident that the two great pillars of material science are physics and biology. Of these the philosophers tell us that physics is the simpler and more fundamental. Physics being also much wider in scope than the other sciences of its own group, as for instance chemistry, geology, or astronomy, is better adapted to those students who in the high school are able to pursue but a single course in science, this course being for many of them not only their first, but also their last, experience in the laboratory.

Now a science which is at once so simple, so fundamental, so teachable, so intimately concerned with what we call "modern civilization," so capable of accurate treatment and so easily followed by the individual student at his private table in the laboratory, as is physics, is eminently adapted for "training in power," and has a purpose in the high school which is almost self-evident.

1. In the accomplishment of this high purpose the first condition of success refers to the instructor. For without the possession of high ideals and accurate scholarship it is difficult to

see how any teacher can efficiently aid his students in the development of power. An instructor devoid of these qualities may stand by and *observe* the growth of his pupils; but this growth will occur rather in spite of him than because of him.

That environment which will allow the lad to grow steadily and healthfully by his own effort must be scholarly and high-minded.

2. A second condition for the success of this fundamental purpose refers to both the matter and the manner of presentation which for the moment are inseparably connected. These must be such as to convince the average good student that he is at work upon something which is really vital to his present and future best interests.

It matters not whether the topic be practical or theoretical, whether disciplinary or entertaining; it must, in any event, be worth while. Touching our daily life as closely as it does, physics allows us to realize this condition as easily perhaps as any other subject in the high school curriculum.

3. Is it not also a condition of success that we look far beyond the present and aim to make the presentation of physics such that it will remain with the student throughout life as an example of correct analysis and clear reasoning? The project is certainly ambitious. The more so since the end must be attained generally without the student's conscious knowledge of the process. But the possibility of success has been demonstrated time and again.

Closely related with this is another worthy object, namely, the cultivation of a keen sense of responsibility. "What is the great word?" Colonel Parker used to ask his little folks; in reply to which they would all pipe up, "Re-spon-si-bi-li-ty!"

Every physical laboratory should be a spot which the future man may look back upon as, at least, one of the places where he learned that the really serious matter in life is to meet each individual responsibility as it comes along. Here he must learn to avoid the expression—or at least the habitual expression—of what is called, in Colorado, a "horseback opinion"; in Chicago, a "curbstone judgment."

4. Lastly, it must not be forgotten that accuracy and order are the first steps toward morality. These are learned from no book. A course in physics is what it is, not in virtue of text or laboratory equipment, but in consequence of the teacher's spirit. Accuracy and the power of close observation go hand in hand.

It is, indeed, quite as much a matter of accurate discrimination to omit irrelevant facts and figures as to include all the significant ones.

To see the essentials and see them clearly is for teacher and taught alike a worthy ambition.

V. By H. L. Terry,

State Inspector of High Schools, Madison, Wis.

You ask, "What should be the purpose of the instruction in physics in the secondary schools?"

The great purpose should be to bring the pupil to understand as fully as possible the laws and principles underlying the natural phenomena constantly taking place about him. We should first of all teach how physical phenomena take place and the principles which seem to be manifested in the phenomena.

The explanations of the teacher, the study of the text, the laboratory experiments and concrete mathematical problems should all have as their object the accomplishment of this end. We must, of course, deal to a greater or less extent with quantitative relations, but the closely accurate quantitative study must follow the above and be strictly subordinate to it.

In contrast with this purpose is that which has a large number of followers, but which, I believe, is mainly responsible for the unsatisfactory condition of the subject in our high schools; namely, that physics is in its nature an exact quantitative science; that it is the only such science in our high school course and should, therefore, be treated quantitatively. When this purpose is in view it leads to the use of absolute units, closely accurate measurements, extended application of formulas and involved mathematical operations unprofitable for the great majority of pupils of high school age. It results in mechanical work without a real appreciation of what is being done and creates a dislike for the study instead of a genuine interest in it.

VI. By Professor H. N. Chute,

High School, Ann Arbor, Mich.

It ought not to be necessary in these days of great advancement along all educational lines to discuss the purpose of the study of

physics in our secondary schools. For twenty-five years, both in conference and in educational journals, the problems of science teaching have been discussed from every conceivable and inconceivable point of view, and if anything new remains to be said, it would be difficult to determine what that could be.

I wish it to be understood at the outset of this discussion that I am not one of those who would have us believe that the teaching of physics is universally in a very bad way, that the courses offered in our schools are little better than barren wastes, utterly without value in any direction, that our classes are wholly without enthusiasm, and that our text-books are only fit for schools for the feeble minded. On the contrary, I maintain that at no time in the history of science teaching have such sane methods been used, and has such effective work been done, as our schools are doing at the present time. Never before were there so many enthusiastic, wide-awake teachers as now, and still it is equally true that at no time has the success of the work in physics been in greater danger than at the present, through the persistent declaiming in conference and in magazine over the horrible condition of physics teaching by a few apparently given to many words and little wisdom. And as you might expect, each of these complainers has a remedy to offer, guaranteed, if tried, to effect a thorough cure. These are a few of the prescriptions: Cut out all mathematics; eliminate all quantitative demonstrations; let the pupils work with rough and crude apparatus for fear that they would not appreciate the finer and more delicate if they ever have an opportunity of using such. One would sacrifice accuracy and perhaps add some Munchausen features, if necessary, to develop interest; would abandon the idea of teaching physics for mental discipline, and would make it wholly an informational subject, a collection of wonders to be admired, and, if possible, remembered. Another tells us that our teaching is a failure because pupils after a forty weeks' course cannot explain correctly many of the commonest phenomena of nature, and fail to observe so many of the little things that take place around them. In this connection I am reminded of the following incident that may help us see this objection in its actual value: "'How many seed compartments are there in an apple?' queried the school inspector of the class before him. No one knew. 'And yet,' said he, 'all of you eat many apples in the course of a year, and see the fruit every day. You must learn to notice the little things

in nature.' The teacher next day overheard this conversation: A little girl had gathered a number of her companions about her and was playing school. She was heard to address them as follows: 'Now, children, just s'pose that I am Mr. Inspector. You've got to know more about common things. If you don't you'll all grow up to be fools. Now tell me,' she said, looking sternly at a playmate, 'how many feathers has a hen?' "

The critics of present methods would also have us believe that because the classes in physics are not crowded, therefore, the methods are at fault. They take their statistics from schools where physics is optional and fail to discern the signs of the times. Never before has the social life in our schools made such large demands on the pupils' time. In these days, a pupil is frequently asked to spend two or three afternoons per week in attendance on athletic functions; to be up-to-date he must be a member of some club, fraternity, or clique and devote many hours per week to promoting its interests; he must interest himself in class politics, get a place on one or more committees, attend the numerous class socials, and so on indefinitely.

It would seem that if physics is to be studied for any purpose worthy of mention, it of necessity must demand of the pupil much of the time that he now devotes to these various things mentioned above, and the consequence is that when physics is not compulsory he cuts it out of his course, and where it is compulsory, he enters upon it under protest. Few pupils study any subject from a firm conviction of its value. They have not reached that stage of development where sound judgment plays any serious part in their choices. It will be remembered that as soon as Greek was made optional for admission to college, it disappeared almost entirely from the curricula of our schools for want of pupils desiring to study it. Is it now in order to announce that the large decrease in the number of pupils studying Greek is due to the unattractive and unpedagogical method of teaching it? Let solid geometry, algebra, or any other subject bristling with difficulties and exacting much time from the pupils be made optional and you will witness a similar falling off in attendance on classes in these subjects. The kindergarten spirit has struck our secondary schools, boys and girls must be amused, must be coddled and given a good and easy time in school or the up-to-date parent will know the reason why, and teachers will be arraigned at conference and in journals for starving their poor

minds, torturing them perhaps before their time, giving them bread when their cry was for candy.

Why should the purpose of teaching physics be in any way different from that of teaching any other subject, namely, that of training the mind in all directions in which it may be called upon to act? It is true that all subjects do not have equal educational value, equal possibilities for mental discipline. But of Physics it can be said that its reach is as far, if not farther than that of any other subject, touching as it does eye, hand, memory, and reasoning powers alike and in a most effective way.

I would teach physics for its informational value, for its magnificent training through the laboratory in the systematic doing of things, for its cultivation of the imagination in grasping its beautiful theories, for its usefulness to the individual in the affairs of life, and for the happiness that the knowledge of the "how" and the "why" of things about him must confer upon the possessor. A gifted teacher has said, that "it is through Physics that we may view and understand a great deal about the various parts of this complex and wonderful universe. It makes manifest to us so many of its laws, discovers its wonderful harmonies and displays the wisdom and omnipotence of the all-wise Creator. It is in these far-reachings of the mind that the imagination has full scope for its loftiest flights and ample space for its fullest exercise. It is not led astray by any false ideal nor fed by any illusive vision, but is ever directed by the firm principles of reason, and in its revelations the ideal and the real are united by the fixed laws of eternal truth."

It thus appears that there are at least two important aims in teaching physics: first, to give interesting and at the same time useful information about the facts of the material universe, and, secondly, and the more important of the two, to develop the pupil's powers of observation, to train him to work systematically and intelligently, to record facts accurately, neatly, and intelligibly, and to reason from facts observed to general underlying principles. To bring these things about much care and thoughtful study must be bestowed on the method of presentation, the teacher must know his subject both theoretically and experimentally, he must be able by simple illustrations successfully presented to make difficult conceptions clear, dry parts attractive, and the whole subject a delight. Cutting out the mathematics will not do it, for the backbone is gone; omitting mechanics will

not do it, for then explanations of phenomena become largely impossible; dropping quantitative work will not do it, for then the pupil will have no proper appreciation of the way in which the science grows and will think of it merely as a jumble of amusing phenomena. A live and well-informed teacher can make mathematics interesting, quantitative experiments entertaining, and the whole subject attractive as well as instructive without resorting to Leyden jar methods to command interested attention. In these days of excellent apparatus at moderate prices, there is no sufficient reason for schools not being well equipped and the work in physics put on a plane such as I have indicated, provided superintendents, principals, and school boards are fairly disposed and will measure the science teacher's time with an equitable rule and place a just valuation on the service he is expected to render.

A PRESSURE TUBE FOR MEASURING THE PRESSURE IN WATER PIPES.

A graduated Torricelli's tube of 100 c.c. capacity is used. A rubber tube attached to the faucet is allowed to fill with water, the faucet closed and the open end of the graduated tube pushed into the rubber tube and tied tightly. After placing the glass tube in a vertical position and opening the faucet, the air in the graduated tube is compressed and by means of Marrotte's law the water pressure at once read off.

The water level is often in constant motion due to the use of water at other outlets.

In a muffle furnace the temperature in the center is lower than near the walls. This fact caused a peculiar error in a factory which formerly used muffle furnaces and then introduced the electric furnace. In the muffle furnace the temperature for hardening the different kinds of steels had been carefully determined in the central zone of the furnace. When the same temperature was then produced in the electric furnace it was found to be not sufficient for hardening. The reason was that the former temperature determinations in the muffle furnace had been made in the center, while the steel parts to be hardened (teeth, edges, etc.) were near the walls. Since near the walls of the furnace the temperature was higher than that measured in the center of the furnace, the measured temperature did not give the correct hardening temperature. For the electric furnace with its absolutely uniform temperature, a higher temperature had, therefore, to be employed than existed in the center of the muffle furnace.

THE MACHINE WITH FRICTION.

By Francis E. Nipher,

Washington University.

In text-books on Physics the pulley and inclined plane are discussed on the theory that they are frictionless. This seems to me to be needless even in the work of the high school.

I present a discussion which has been used for many years in my laboratory instruction.

The force P required to slide a body on a horizontal surface is $P=f\,R$, where R=weight of the body f=coefficient of friction. In general R is a force at right angles to the surface of contact and P is at right angles to R.

By reason of such frictional contacts every machine for transmitting energy delivers less than it receives.

Let P and p represent force applied to any machine, and distance over which the force is exerted. Let R and r be the force delivered and the distance over which it is exerted, r and p being simultaneous values.

Evidently the work applied is equal to the work delivered plus the work lost in friction, when in uniform operation. Let I= lost work of friction.

$$Pp = Rr + I \quad \text{..........(1)}$$

It is evident that the ratio r/p is a fixed quantity for any given machine. It depends on the gearing. Eq. (1) may be written:

$$\frac{P}{R} = \frac{r}{p} + i \quad \text{..........(2)}$$

$$i = \frac{I}{Rp}$$

Experiment shows that P/R is also a constant for any machine. It follows that i is constant. It may be called the friction constant for the machine.

Similarly if R is the driving force

$$\frac{R}{P} = \frac{p}{r} + i' \quad \text{..........(3)}$$

In (1) and (2) it is assumed that the machine is first adjusted to uniform motion and that P and R are the loads or forces added after such adjustment.

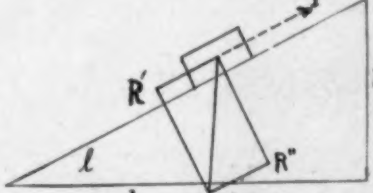

Fig. 1.

For the inclined plane where P is parallel to its surface as in Fig. 1 and a the angle of inclination,

$$P - R' = fR''.$$

Here R′ and R″ are components of the force R, which is the weight of the mass on the plane. By similar triangles, h, l, and b, being height, length and base of plane the last equation becomes

$$\frac{P}{R} = \frac{h}{l} + f\frac{b}{l} \quad \text{.......................... (4)}$$

Hence the friction constant is

$$i = f\frac{b}{l} = f\cos a \quad \text{.................... (5)}$$

If the body moves uniformly down the plane against the pull P_1 (P being diminished to P_1)

$$R' - P_1 = fR''$$

$$\therefore \frac{h}{l}R = f\frac{b}{l}R + P_1$$

By (3)

$$\frac{R}{P_1} = \frac{l}{h} + i'$$

Eliminating $\frac{R}{P_1}$ in these two equations and solving for i'

$$i' = \frac{f\cos a}{\sin a(\sin a - f\cos a)} \quad \text{.................. (6)}$$

The relation between the constants for direct and reversed action is by (5) and (6)

$$i' = \frac{i}{(\sin a - i)\sin a} \quad \text{.................. (7)}$$

In a similar way when the applied force P acts parallel to the base, as in the screw we have for direct driving

$$i = \frac{f}{\cos a(\cos a - f\sin a)} \quad \text{.................. (8)}$$

For reverse action

$$i' = \frac{f}{\sin a(\sin a - f\cos a)} \quad \text{.................. (9)}$$

The same treatment may be applied to shafting.

Let a shaft of radius r_1 be supplied with two pulleys of radii r_2 and r_3. The loads in the form of weights R and P are to be applied to these pulleys. Let P_0 be the weight on r_3 which will drive shaft alone at uniform speed. The shaft slips in its bearing on a line such that a plane tangent to the shaft in that line will make with the horizontal plane an angle that $\tan a = f$. The moments balanced on this line will be

$$P_0\,(r_3 - r_1 \sin a) = m\, r_1 \sin a \text{ .... (10)}$$

where m is the weight of shaft and pulleys. Additional loads P and R are added to the pulleys. These additional balanced moments are

$$P\,(r_3 - r_1 \sin a) = R\,(r_2 + r_1 \sin a).$$

Since $\sin a = \dfrac{f}{\sqrt{1+f^2}}$ the last equation may be written

$$\frac{P}{R} = \frac{r_2 + r_1 \sin a}{r_3 - r_1 \sin a} = \frac{r_2\sqrt{1+f^2} + r_1 f}{r_3\sqrt{1+f^2} - r_1 f} \text{ .. (11)}$$

By Eq. (2) we also have

$$\frac{P}{R} = \frac{r_2}{r_3} + i \text{ .... (12)}$$

By (11) and (12)

$$i = \frac{r_1 f\,(r_2 + r_3)}{r_3\,(r_3\sqrt{1+f^2} - r_1 f)} \text{ .... (13)}$$

In a similar way for reversed driving

$$i' = \frac{r_1 f\,(r_3 + r_2)}{r_2\,(r_3\sqrt{1+f^2} - r_1 f} \text{ .... (14)}$$

These equations were tested by means of a shaft mounted in wood bearings and provided with a single pulley. The weight R was hung on a cord 0.2 cm. in diameter. The diameter of the shaft was 3.05 cm. and that of the pulley was 30.0 cm.

Let $P_\delta = P_0 + P$ of Eqs. (10) and (11).

Let R_s be the corresponding value for reverse driving. Then

$$P\delta = P_0 + \left(\frac{r_1}{r_3} + i\right) R \text{ .... (15)}$$

$$R_r = R_0 + \left(\frac{r_3}{r_1} + i'\right) P \text{ .... (16)}$$

These equations represent two straight lines shown in the diagram.

These lines intersect at some point a. Here the machine will run either direct or reversed with the same forces P″ and R″. It is then a frictionless machine. P″ and R″ are both negative. The shaft and pulley are in fact hung on the two cords and no contact exists in the bearings. If $m =$

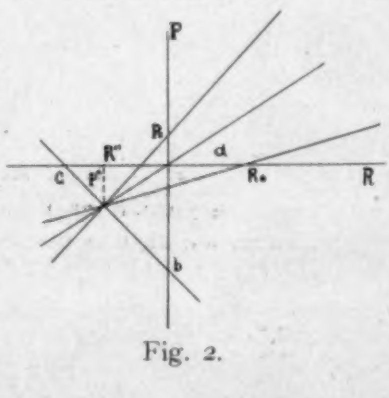

Fig. 2.

the weight of the shaft and pulley we have—$(P'+R'')=m$ or

$$P'' = -m - R'' \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (17)$$

This is the equation of the line $b\ c$ in the diagram. It makes an angle of 45° with the axes of P and R if these values are plotted to the same scale. A line through the origin which cuts line $b\ c$ at the point of intersection of the two lines represented by Eqs. (15) and (16) is the line representing the action of the frictionless machine. For this line

$$\frac{P}{R} = \frac{r_1}{r_3} = \tan \alpha \ldots\ldots\ldots\ldots\ldots\ldots (18)$$

if correction be made for the thickness of the cord. The smaller cord was a bundle of silk fibers, and needed no correction. For the numerical values we have

$$\tan \alpha = \frac{1.52 + 0.1}{15} = 0.108$$

The reciprocal or $\frac{r_3}{r_1} = 9.26$.

The following observations were made, the values P_δ and R_r being the means of values obtained by changing the cords from one side to the other of pulley and shaft. These independent values differed by from one to three per cent.

Direct		Reverse	
P_δ	R	P	R_r
124	0	0	1382
1135	8165	587	8165

For direct driving the observations give two equations from which

$$P_0 = 124\ , \quad \frac{r_1}{r_3} + i = 0.1238.$$

Similarly for reverse driving

$$R_0 = 1382 \quad \frac{r_3}{r_1} + i' = 11.56.$$

The equations for the two lines (15) and (16) are

$$P_\delta = 124 + 0.1238R$$
$$R_r = 1382 + 11.56P.$$

In these equations if we make $P_s = P$ and $R_r = R$ we have by elimination the coördinates of the intersection, $P''=-684.1$

$R''=-6528$

Hence

$$\frac{P''}{R''} = \frac{684.1}{6582} = 0.1048$$

The reciprocal of this value is 9.54. This value differs somewhat from the value determined from the radii of shaft and pulley as given above, and is undoubtedly more accurate. Adopting this as the ratio of motion we have

$$i=0.1238-0.1048=0.0190$$

$$i'=11.56-9.54=2.02$$

In Eqs. (13) and (14) we must make $r_2=r_1$. If we make

$$\frac{r_1}{r_3} = \rho = 0.1048 \text{ and } \frac{r_3}{r_1} = \delta = 9.54$$

these equations become on solving for f.

$$f = \frac{i}{\sqrt{[(i+1)\,\rho + \rho^2]^2 - i^2}} = 0.163$$

$$f = \frac{i'}{\sqrt{(i' + \delta + 1)^2 - i'^2}} = 0.162$$

These two determinations of f are wholly independent of each other.

It will be observed that the determined values of P″ and R″ in Eq. (17) give for m a value 7212. The pulley and axle weighed 6624 grams. This difference is accounted for by very slight errors in the slope of the two lines for direct and reverse motion, which make a small angle with each other, and which have a small slope. This would result in rather large possible errors in the sum of these quantities without materially affecting their ratio.

By making $P\delta=P=P''$ and $R\delta=R=R''$ in Eqs. (15) and (16), and remembering that $P''/R''=r_1/r_3$ it may easily be shown that

$$\frac{P_0}{R_0} = \frac{i}{i'}\,\frac{r_3}{r_1} = \frac{i}{i'}\,\frac{R''}{P''}$$

By Eqs. (15) and (16) and (17), making $P\delta=P=P''$ and $R_\delta=R=R''$ in the former the values of P″ and R″ are easily seen to be

$$P'' = -\frac{r_1}{r_1 + r_3}\,m \quad R'' = -\frac{r_3}{r_1 + r_3}\,m.$$

Also that

$$P_0 = \frac{r_1 f m}{r_3\sqrt{1+f^2} - r_1 f} \quad \text{......................(19)}$$

$$R_0 = \frac{f m}{\sqrt{1+f^2} - f} \quad \text{......................(20)}$$

The last equation also follows from Eq. (20) by making $r_2=r_1$. It will also be seen (19) that δ is identical with (10). From this equation (20)

$$f=\frac{R_0}{\sqrt{m^2+2m\,R_0}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(21)$$

By means of this equation the coefficient of friction of the shaft on its bearings may be determined. It is only necessary to determine the weight m of the shaft, and the driving load R_0. The load should, however, be carried on a thin ribbon, in order that r_2 may be really no greater than r_1.

AN ALWAYS READY SIPHON.

A U tube (chloride of calcium tube) with a small tube sealed into the bend is used. The small tube is closed by a piece of rubber tubing and pinch cock. Both ends of the U tube have tied over them about three layers of fine muslin, through which water will flow quite rapidly. By placing the muslin covered ends under water and sucking on the unclamped rubber tube the siphon is filled and after closing the pinch cock it may be moved about, hung up or laid down without the water flowing out.

As soon, however, as one arm of the vertical siphon is partly immersed in water, the latter begins to flow from the other arm. This device is useful in bringing to the same level liquids in two cylinders, to protect a cooling bath into which water is constantly running from overflow, and to remove water from the surface of mercury in a dish, when inclined.—*Chemiker-Zeitung.*

THE PRODUCTION OF FULLER'S EARTH IN 1907.

Fuller's earth, a very absorbent clay that was first used for taking grease spots out of cloth, is now used in the United States chiefly for clarifying oils.

Florida furnished nearly seventy per cent of the entire output of fuller's earth in the United States in 1907. Arkansas, Georgia, South Carolina, Massachusetts, Colorado, and Texas also contributed to the production, ranking in the order named. The total production of the United States in 1907 was 32,851 short tons, valued at $291,773, the largest production and value yet reported. The imports were 14,648 long tons, valued at $122,221, the largest quantity imported in any one year since 1903 and the largest recorded value in any year.

An advance chapter of "Mineral Resources of the United States, calendar year 1907," on the production of fuller's earth, by F. B. Van Horn, just published by the United States Geological Survey, furnishes the statistics reported. The paper contains a discussion of the causes of the bleaching power and clarifying action of fuller's earth, a question that is of considerable interest to chemists.—*U. S. Geological Survey Bulletin.*

AN APPARATUS FOR PLOTTING MAGNETIC FIELDS OF FORCE.

By E. J. Rendtorff,

Lake Forest Academy, Lake Forest, Ill.

One of the standard experiments in the physical laboratory of secondary schools is the plotting of magnetic lines of force. This is generally done by soaking a piece of a paper in paraffin, allowing it to dry, placing the magnets on the hardened paper and then scattering finely powdered iron filings over the field. The application of heat melts the paraffin and sets the filings.

This is a poor method for large fields, where the magnetic force is weak, and seldom brings out the critical zones, except when they occur near the poles of the magnets.

A much more satisfactory, though slower, method is by means of the apparatus illustrated in Figs. I. and II. A small agate bearing magnet, about 2 cm long, is pivoted on the needle F.

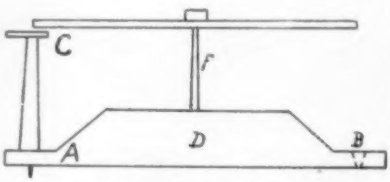

Fig. I.

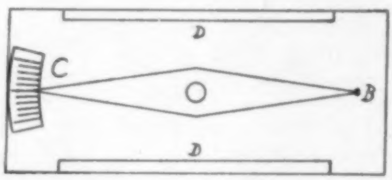

Fig. II.

One end of the magnet swings over a divided scale *c* and when directly over the center of the scale the other end is above the hole B. A is a short, sharp needle point and D a convenient support for moving the base of the apparatus.

On a piece of paper about two feet square adjust the various magnets, pieces of magnetic and nonmagnetic metals as desired, and draw their outline. Also mark the cardinal directions on the paper. Place the apparatus anywhere on the paper, pushing the point A well into it. Revolve the base until one end of the magnet is directly over the zero of the scale (and therefore above the point A) and mark the hole B with a sharp needle point. Now move the needle A to the former position of B and continue as before. In this way the entire field can be plotted and the critical zones accurately determined.

THE MONUMENT TO ROBERT BUNSEN.

By Nicholas Knight,

Cornell College, Mount Vernon, Iowa.

Some four or five years ago an appeal was sent out to the members of the German Chemical Society asking contributions for a suitable monument to the memory of Robert Bunsen. The monument was to be erected in Heidelberg, where the great teacher and investigator had labored so successfully for thirty-seven years, from 1852 to 1889. The admirers of Bunsen throughout the civilized world generously responded, and with some assistance from the city of Heidelberg 70,000 marks were contributed for the memorial.

The monument was unveiled on August 1 of the present year. It consists of a life-size figure in bronze of the distinguished scientist, representing him as he appeared in 1859, about the time that he and Kirchhoff invented the spectroscope. In one hand he bears a manuscript, as if about to deliver a lecture. A flight of a few steps leads from the street to the monument. On each corner of the monument plot nearest the street is a colossal figure of white granite from the Black Forest, one representing the known sciences, and the other science awaking. The monument is not far from the Heidelberg Chemical Laboratory, a part of which was constructed under Bunsen's supervision, and was afterward added to by his illustrious successor, the late Victor Meyer. The designer of the memorial is Professor H. Volz of Karlsruhe, and from an artistic standpoint it is a meritorious work.

The exercises connected with the unveiling were simple but interesting and impressive. Music was furnished by the city orchestra, led by Professor Grau. Professor Theodore Curtius, the director of the Heidelberg laboratory, the successor of Bunsen and Victor Meyer, as a member of the monument committee, gave an interesting detailed history of the enterprise. Professor Bernthsen, representing the industrial chemists, spoke at length of the great debt applied chemistry owes to the investigations of him to honor the memory of whom they were assembled. He spoke of Bunsen's contributions to industrial chemistry by the spectroscope, by his discovery of important technical analytical methods, by his work in volumetric analysis, contributing to the subject a new chapter on iodimetry; by his studies in gas analysis; by his improved methods of iron production, and by his sep-

aration of various metals by electrolysis. Bernthsen was formerly a student and colleague of Bunsen, and he could speak with some authority. The mayor, Dr. Wilckens, accepted the monument in the name of the university city. Representatives of the German Chemical Society and a score of similar organizations deposited upon the monument laurel wreaths and other floral tributes suitably inscribed, as a mark of esteem for the man who so ably served his day and generation. Besides the scientific organizations, many of the German universities and technical schools sent their representatives and floral offerings to do honor to the occasion which proved a notable day in the history of the city. The exercises were largely attended, and several members of Bunsen's family were interested spectators.

Bunsen was not only one of the foremost scientists of his day, but he was a good citizen and an amiable man, beloved by all classes. He received many honors in his lifetime. The name of the street on which he lived during the ten years that he was professor *emeritus* was changed to Bunsen Strasse—rather an unusual honor, but one richly deserved.

Bunsen came to Heidelberg as professor at the age of forty-one. During the thirteen years previous, he had served the universities of Breslau and Marburg, at both of which his work justified the expectations that were realized at Heidelberg.

Some of the visitors to the unveiling ceremonies wandered to the cemetery of the old university town on the Neckar, and sought out the grave of the great scientist. The monument is plain and simple and bears a simple inscription. The mound is covered with rhododendrons. Not far away is the granite block, almost overgrown with ivy, which marks the last resting place of that other world renowned scientist, Victor Meyer, the worthy successor of the immortal Bunsen.

A SIMPLE METHOD FOR DETERMINING THE EQUIVALENT WEIGHT OF SODIUM.

By William M. Blanchard,

DePauw University, Greencastle, Ind.

One of the laboratory exercises usually assigned students of general chemistry early in their course is the determination of the equivalent weights of some of the more common metals. In order that the results may be used subsequently in introducing

the idea of valence, zinc and aluminum are commonly chosen, their equivalent weights being obtained by collecting the hydrogen evolved when a given weight of the metal is dissolved in an acid.

In order that a more complete series may be obtained, it is evident that the equivalent weight of such a metal as sodium should be added to the list. The decomposition of water by a given weight of this metal is the method naturally suggested, but owing to the difficulty of weighing accurately small quantities of sodium and to more or less danger connected with its use, the experiment is not usually attempted. One way out of the difficulty is to follow the old suggestion of Davy, that is, to make an amalgam with mercury, weigh out a definite amount of the amalgam, bring it in contact with water in a suitable vessel, collect the hydrogen, and determine the weight of the sodium by drying and weighing the residual mercury. The weight of the sodium is found by taking the difference between the weight of the amalgam and the weight of the mercury recovered.

A much more convenient method is the one described below. It has the merit of simplicity, it is easily manipulated, is quite accurate, free from danger, and can be completed in a few minutes.

Select a smooth piece of ordinary tin foil about 4 cm. square and weigh it accurately. Cut off a piece of sodium approximately 5 mm. square and 1 mm. thick, press it quickly two or three times between filter paper, trim off any corroded edges with a sharp knife and quickly wrap it tightly in the tinfoil, pressing down the corners so as to exclude all air. Weigh the tin-foil with the sodium. The difference between this and the previous weight gives the weight of the sodium.

Fill a 100 cc. eudiometer with distilled water, invert it in a 100 cc. porcelain dish and clamp it so that its mouth is about 1 cm. above the bottom of the dish. Slip the tin-foil containing the sodium under the mouth of the eudiometer, withdraw most of the water from the dish, and with a sharp pointed instrument (file) slightly bent near the sharp end, make a small puncture in the tin-foil. In a minute or two make another puncture if necessary. After it is certain that all the sodium has reacted with the water, determine the volume of the hydrogen in the usual way, calculate its weight and from it calculate the equivalent weight of sodium. The result will be found quite satisfactory.

A LABORATORY EXERCISE ON THE EFFICIENCY OF A SMALL MOTOR.

By N. F. Smith,

Olivet College, Olivet, Mich.

An exercise on the study of a small electric motor is commonly included in the high school course. Unless carefully handled, this exercise is liable to degenerate into mere play. In the course given in the Olivet Preparatory a quantitative determination of efficiency has been included in this exercise. Without being especially difficult, this has proved to be one of the most profitable experiments in the course, and one in which the students are most interested. It has been performed as follows:

The pulley on the shaft of the armature is removed and a thread one or two meters in length is attached to the shaft by a bit of wax. A suitable weight is hung from the end of the thread. As the armature revolves the thread is wound on the shaft and the weight is lifted. An ammeter and volt-meter are used to measure the current and electro-motive force respectively. The motor is started and the time required to lift the weight to a given height is measured by a stop-watch. At the same time ammeter and volt-meter are read. To accomplish this four persons may to advantage work together. The product of the current in amperes times the E. M. F. in volts times the time in soconds gives the energy supplied in joules. The product of the weight in grams times the height in centimeters times 980 times 10^{-7} gives the work accomplished in the same units. The quotient gives the "commercial efficiency."

Coal, when exposed to the action of the air, loses from 2% to 10% of heating power. This deterioration continues about 5 months, decreasing in amount during this time.

The pig-iron production of the United States for 1907 is placed at 25,781,361 tons, as compared with 25,308,191 tons in 1906. The Canadian production was 581,146 tons in 1907, against 541,957 tons in 1906.

By adding 0.01% of aluminum to molten steel, blistering and fissuring in the ingot is readily avoided. The aluminum absorbs the oxygen present and makes the steel very fluid by disengaging heat.

SCIENCE TEACHING IN SCHOOLS.

By Arthur S. Dewing,
Harvard University.

A study in the relation of science teaching to the general problems of education.

(Continued from the November issue.)

III. Science Teaching and the Laboratory Method.

Until comparatively recent years the sciences were taught throughout our schools by means of the old text-book system. Even as late as 1898 it was possible for a student to enter Harvard College by presenting himself with a text-book knowledge of descriptive astronomy and a little physics. This represented the general attitude toward science teaching throughout the schools of the country. Some years ago Harvard was in the forefront of the movement to replace the old text-book method of teaching the sciences by something more vital and significant. This was over a decade ago. The movement toward the laboratory method of teaching the sciences, which had been gaining ground for the twenty years before, is now universally recognized, at least in theory. An acceptance of the laboratory method in theory, however, is a far different thing from its practical application. So much has been said against the old text-book method and so much in favor of the laboratory method that it is quite the fashion to speak of one's teaching as if imbued with the spirit of the new ideas. A few lecture room experiments do not constitute a laboratory course, nor even a few experiments performed by the pupils themselves with an impatient teacher at their elbow to tell them what will happen in the test tube or what organ will presently come into view. Something more than the mere name, something more than pupils trained to imitate their teacher, is implied by the laboratory method of teaching the sciences when this is rightly understood.

The defects of the old text-book method of science teaching have been so often reviewed that it is hardly necessary to recur to them. Text-books have no imagination. Their facts are presented with as much certainty as if the author had intercourse with the Deity. The effect on the fertile imagination of young students is deadening in the extreme. Science becomes a lifeless stock of facts, and the struggling student acquires as narrow a

view of nature as the crude recital of these facts permits. In brief it may be suggested that the educational faults of the text-book system cluster about three cardinal errors—the teaching according to the text-book method is lifeless, the sources of authority are always second hand, and finally there is required no initiative effort on the part of the pupil. Any improvement in the methods of teaching science must follow lines suggested by these fundamental defects in the older methods of teaching.

The evil results of a narrow perspective in teaching the sciences are widely acknowledged but not altogether avoided. Education, like everything else of human making, has its fashions. At the present time the text-book method of science teaching is out of fashion, and the laboratory method, so called from the constant resort to first-hand observation, is in fashion. Any teacher, therefore, who wishes to eulogize his own method of teaching is sure to characterize his work as thoroughly in sympathy with the modern trend of laboratory teaching. There is, however, a profound difference between the letter of the laboratory method and its spirit. The mere presence of a stuffed bird in a school room does not transform dull and lifeless study to a vital appreciation of nature. Something more than well-equipped laboratories are necessary to make pupils feel what science means—until they feel, not merely know, science teaching is the dull routine of tasks forever undone because they are forever misunderstood.

The modern laboratory method has grown out of the endeavor to transcend the difficulties and misconceptions of the older methods of science-teaching. It has resulted through evolution, through a consistent process of trial and error in educational theory. As an educational method it depends, as it has depended for its conception, upon the atmosphere which the teacher creates, upon the spirit with which it is understood. This is said with much emphasis because most teachers of science find a laboratory at their command, either by virtue of state requisition or the trend of fashion, and its use or abuse depends on the teacher and on him alone. It is almost a commonplace to say that there is more educational benefit to come from a good teacher in a poorly equipped laboratory than magnificent laboratory facilities at the command of a lifeless teacher. Merely having a laboratory, then, does not signify that the spirit of the laboratory method is even partially realized. Two things are inseparably

linked together in the modern method of science teaching—the laboratory method as the outward expression of the way in which facts are taught, the inductive method as the inner expression of the way conclusions are reached. Each presupposes the other. There can be no reliable induction without first-hand observation, and first-hand observation is utterly valueless unless followed by careful inductive reasoning on the part of the pupil. Science must be taught as if it were a living subject, capable of itself of exciting human interest by a first-hand acquaintance with facts. These facts of personal observation, moreover, must be shown to lie at the basis of all the generalizations of science. When the pupil is made to realize these things for himself, the laboratory or inductive method of science teaching has some real significance in the routine of daily tasks.

The first consideration of the laboratory method is in manner of obtaining the observations. A laboratory can not take the place of the spirit which a teacher creates, yet it is a great help in obtaining results that are worth while. Material equipment is not all there is in education, but in the present stage of science teaching, when there is a minimum of time to be wasted and a maximum of results to be achieved if science teaching is to hold its place, then good laboratory facilities are almost essential. A laboratory need not be full of expensive apparatus—very accurate apparatus kept in glass cases to be occasionally used by the teacher has very little educational value. In general, apparatus ought to be of the simplest type so that each and every student may perform the experiment or make the personal observation. Skill in manipulation is a highly desirable thing and comes only with practice. In a general way it may be said that lecture table experiments do little more than waste the time of the student. There are so many experiments and observations which the student can conduct himself—so many more than the limited time makes it practical to use—that the utmost care should be used in making every minute tell for its utmost worth. A crude experiment, giving only approximate results, that the student carries on alone, one in which he makes his own observation and draws his own conclusions, is of vastly greater educational value than a similar experiment done before the class with more complicated apparatus, even if the results of the latter are much more accurate. Complicated apparatus is difficult for a pupil to understand, he readily confuses the essential and the non-

essential and the moment there is any confusion the attention lags. If, on the contrary, the student is performing the experiment himself, he can not allow his attention to wander from the work before him and he observes what is happening almost by necessity. Brass fittings and a profusion of stop-cocks are apt to detract from the very thing the experiment wishes to express. A tooth-powder bottle and a glass tube, in the hands of the student himself will teach him more about the properties of hydrogen than if he watches his teacher manipulate the best generator the market affords. It were much better for the laboratory to have twenty air-pumps, costing four or five dollars each, than to invest a hundred or a hundred and fifty dollars in a single pump. A few seeds, a little wet sand, and a box with two compartments, one dark and the other light, given to each pupil in botany will teach more about the growth of seedlings than any amount of experiments which the teacher performs himself. One of the first axioms of the laboratory method should therefore run something like this: The crudest results, reached by the pupil through his own individual efforts have far greater educational value than more accurate results reached by the direct assistance of the teacher.

The type of experiment is a matter of a good deal of consideration. General rules in this particular are not easily made, but there is one matter which can not be too strongly emphasized. Of two experiments illustrating much the same principle, that one should be chosen which will require the more constant attention on the part of the pupil. In general, quantitative experiments are always to be preferred to qualitative. The moment a pupil is asked to measure something, to compare quantitatively the size of two images or the weight of two tubes, there is demanded a nicety of observation which no amount of qualitative work will bring into play. Furthermore the student takes the quantitative work more seriously. We instinctively see a dignity in a set of figures which we fail to find in mere qualitative results. The equal expansion of all gases can be taught much better by requiring that the student shall find the number of cubic centimeters that a constant volume of several gases expands when the temperature rises through the same number of degrees, than any experiments which shall illustrate this only qualitatively. Daily measurements made of the growth of two seedlings, one grown in the dark and the other in the light, one in low tem-

perature and one in medium temperature, will teach more than a mere comparison of the growth of two seedlings. Quantitative results can be plotted, the results of different members of the class can be compared, general averages—in many cases surprisingly accurate—can be made. The teacher has an opportunity to suggest that science has always sought to correlate its results with mathematics. A scientific law which can be expressed in terms of some mathematical relation has always been looked upon with greater confidence than a merely qualitative law. The teacher should try to find examples illustrating this from all the sciences—electrical phenomena were little understood until the advent of Ohm's Law, the heat of chemical reaction was a mystery until the Law of Hess and the facts of biological inheritance were in hopeless confusion until Mendel's Law was brought to light. As a whole, then, summing up our position in regard to the observational phase of laboratory work, it may be said that individual work should always be the purpose and that this should be so arranged as to require the maximum of attention on the part of the pupil coupled with a certain accuracy as regards measurable quantities.

(To be continued.)

METRIC SYSTEM USED IN FRANCE.

Regarding the absurd and wicked statement made last year by Lloyd George, then President of the English Board of Trade, that "the Metric System has broken down hopelessly in France," we quote the following abstract of the Report prepared by the French Ministry of Commerce on the Weights and Measures Service in France for the Six Years 1901-6, showing clearly that George made the statement without regard to facts, at a time when truth would have been of value. No censure is too severe for ignorance or disregard of truth by a man in such a position at such a time:

"An official circular was addressed to Chambers of Commerce, etc., in 1906, with respect to the inclusion in trade catalogues of various illegal denominations which were still in vogue in certain industries and businesses *in which sales are not made according to weight or measure* (*e.g.*, saddlers, lamp manufacturers). A certain latitude has been allowed to such traders, but this was only intended to be a temporary measure to facilitate their dispensing with obsolete terms and substituting legal denominations. It was found necessary to issue this circular in order to remind these traders of their liability to penalties. *The replies received to the circular are said* [by the French Minister of Commerce] *to have established conclusively that in France opposition to the Metric System is no longer encountered anywhere.*"

R. P. W.

APPROXIMATIONS AND APPROXIMATION PROCESSES.*

BY PROFESSOR E. R. HEDRICK,
Columbia University, Columbia, Mo.

Incommensurable Ratios. The fallacy just mentioned enters in a general fashion in the so-called "proofs" of the incommensurable cases in geometry. We shall not enter upon these theorems at this point in detail, but shall limit ourselves to a demonstration of the worthlessness of the proofs most commonly given, from which one should conclude that these proofs ought to be omitted for the most part.

Taking a simple instance, let us consider the proposition that the areas of two rectangles whose bases are equal are proportional to their altitudes. Upon some inspection of the most usual proofs, we see that (in the "incommensurable case") the areas in question cannot possibly both be defined under the definition quoted above; hence the theorem states a fact about quantities which are not even defined. If it amounts to anything, when given in this manner, it amounts to a definition of the previously undefined concept of the area of the rectangle whose height is incommensurable. But if this were really the intention, surely a so-called "proof" would be rather out of place. Moreover, the fact stated in the supposed theorem involves the ratio of two heights which are incommensurable; again here, the usual definition of length of a straight line segment leaves such incommensurable lengths undefined. The supposed theorem is therefore a statement about certain hazy, undefined concepts, and the statement is made that the ratio of these undefined things is equal to the ratio of two other undefined things.

Possibly this is bad enough, though I presume it will be said that I am drawing fine distinctions. But if one does not wish to draw fine distinctions, what is the use of this theorem, anyway? For it is in itself an attempt to learn something about that peculiar case in areas in which no common measure exists. Strange, is it not, that one should be anxious to prove theorems which draw fine distinctions about abstruse concepts, while one at the same time argues that these very concepts ought not to be defined because that would be drawing too fine a distinction. Does this not resemble closely the camel-swallower who strains at proverbial gnats? The writer would choose the gnats

and eschew the camels. It is urged that you consider the advisability of doing the small thing of defining what these areas are, but that you leave until a much later time the study of theorems concerning them. The theorems are too hard; the definitions are quite enough, possibly even the definitions are too abstruse. It is not at all objectionable for anyone to omit the whole matter; it is not objectionable if anyone pleases to give the definitions and omit any theorems; it is not objectionable if there be a preference for giving the definitions and then proving a few theorems, provided the proofs really prove anything; but it seems reasonable to object to proofs of some theorems without definitions, or to proofs which rest on a fallacy.

Possibly these arguments will suffice for some minds. The author knows, however, that traditional arguments are dear to the soul, and concludes that an additional *coup de grace* will not be superfluous. For if to anyone of you the proof of theorems about undefined things is endurable, surely no one of you will defend a plain case of *non-sequitur* fallacy in the logical part of the proof. You will remember that in all these "incommensurable case" proofs as usually given, a certain limit theorem is supposedly used, namely that "if two variables are constantly equal to each other, their limits are equal." This limit theorem is of course correct; in fact it is an absurdly trivial statement of a fact which is more than obvious—and utterly useless for any purpose whatever. But in the incommensurable case proofs its meaning is distorted and it is used to cover a fallacy; for the thing which it is there desired to prove is not the preceding statement at all, but rather this one "if two variables are equal for all except the limiting value of a certain controlling independent variable, the two variables are equal for the limiting value of the controlling variable." Now this statement is utterly false, as witness the geometrical progression whose first term is x^2 and whose common ratio is $1/(1+x^2)$: the sum of the (infinite) progression thus defined is $(1+x^2)$ for every value of x except $x=0$; if the reasoning employed in these "incommensurable case" proofs were correct, the sum of the progression would necessarily be 1 when $x=0$, whereas the sum is actually 0 when $x=0$. It follows that precisely the same logical argument used in demonstrating these theorems would also show that $0=1$.

The writer has had a certain cynical pleasure in hearing these so-called proofs for the incommensurable cases defended —not upon the ground of any usefulness of the results, which might really be a defense—but rather upon the ground that they strengthen the reasoning powers! Rather they are a travesty on argument; an abortion of reasoning to which there is scarcely a parallel in all the devious labyrinths of human fallacies. Nor has one of the more complicated among them been chosen for an illustration; purposely the first and simplest of these propositions was chosen. Had the writer desired, he might have found one with a few more flaws; there is no one among them which has less than the one here used for illustration. No question of doubt should be left in the mind of anyone of you about the actual correctness of the theorems themselves. The theorems are all true as usually stated, provided the quantities which enter in them are properly defined. The writer has merely pointed out that the demonstrations usually given do not demonstrate; and he has urged that the definitions be given, with or without the (correct) proofs of the theorems.

Limits.—I have mentioned that any approximation process furnishes numbers whose limit is the quantity approximated. All questions involving the kind of limits which occur in elementary (secondary and primary) mathematics can be treated upon this simple basis, and the word limit need not be introduced. As a justification for the advice to omit all treatment of limits, the writer would submit that there is scarcely a popular text-book upon the market to-day in which this topic is correctly treated, while in many popular texts the treatments are positively absurd. Does it not follow that a topic so abstruse as to cause the writers of texts to flounder, is not quite the thing to present to children? For this reason then all discussion of limits will be entirely omitted from this paper, except to advise this omission of all reference to it, including the bizarre theorem quoted above.

Simply as a hasty justification to those who are quite expert in handling limits, the writer will say that the remark made above, "that there are limits which do not correspond to approximation processes," refers to limits taken over an assemblage which is not countable; for it is evident that a true mathematical approximation process corresponds to a limit taken on an enumerable assemblage.

The Fetich and the Taboo in Certain Approximation Processes. Our traditions have given rise to certain curious prejudices regarding approximation processes which resemble closely the fetiches and the taboos of certain aboriginal peoples. From a logical standpoint there is, of course, no reason for these prejudices. There is no real distinction, in principle, between one process of approximation and another, provided they both fulfill the requirements mentioned above, and provided both are valuable. Hence, since approximation processes are necessarily recognized as perfectly good mathematics,—because, in fact, many portions of mathematics depend vitally upon such processes,—there appears to be no justice in any discrimination against any given one. Several need only be quoted, however, without any explanation, in order to make the actual prejudice vividly clear.

The ordinary process of square root is one of the fetich class. It is certainly recognized as absolutely legitimate, and one scarcely questions the propriety of asking a student to solve a problem which involves finding a square root;—it is usual to say that such a problem can "be solved."

Contrast this state of affairs with the taboo against the trisection of any angle by means of ruler and compass. It is usual to say that this problem cannot "be solved." Yet I can surely trisect an angle by means of compass and ruler in precisely the same sense in which I can find the square root of three, for the latter is an approximation process, and it is perfectly easy to set up a good, and very rapid, approximation process for trisecting an angle by compass and ruler, if one only starts by random choice of a trial trisection somewhere between one-half and one-fourth the given angle, and then proceed by successive steps in a perfectly natural manner. The process just suggested is eminently practical and useful; it is precisely as justifiable as the process for finding square root; it has all the necessary qualifications of a good mathematical approximation process; it is the process actually used by all draughtsmen and mechanics. Yet who ever heard of such a thing as teaching this eminently practical, useful, and thoroughly mathematical process, simple as it is, in a course on geometry? If some of you have actually done this—may your race increase!—have you not done it almost furtively, somewhat apologetically? Have

you not thought that it was not really mathematics? For the most part certainly this process is not given, it is tabooed. Instead we give a fallacious proof of a useless "incommensurable case," and rub our hands in smug satisfaction over the accomplishment of something really "mathematical"—forsooth!

I should mention also that if anyone of you has to divide a circumference into five equal parts, I can commend to him most heartily that he do so by approximations, rather than by the ordinary construction; and that he do so boldly, knowing and asserting most strenuously that he is doing just as mathematical a piece of work as was ever done. We should beware lest our less assuming brethren of the drawing department, who have already appropriated the vital part of solid geometry in the space conceptions of so-called descriptive geometry, do not take the substance and leave to us, teachers of mathematics, only the shadow. Incidentally, some of this mathematics, the trisection of an angle, for example, might be done in the graded schools. And make very sure that no one frighten you into thinking it is not mathematics, of the purest and simplest sort. The writer knows of no instance of an approximation process of the pure type which is so simple, indeed, as this one.

As another contrast to the fetich of the square root process, let us consider a rule for square root which is used frequently by carpenters and other mechanics. It is a perfectly pure approximation process, as is the usual square root process; it is not contained in any arithmetic with which I am acquainted; it is at least as simple as the usual process, though it is not so elegant; it possesses two enormous advantages: (1) any person can understand it at once; (2) no person can possibly forget it after he has worked as many as two problems with it. Yet the writer is convinced that it would be tabooed, that it would not be accepted as an explanation of finding square roots on an examination paper, for example, by county or state examiners. It consists simply in dividing the number whose square root is to be found by a trial square root, which may be as bad a guess as you please. If the guess is too high, the quotient is smaller than the divisor, and *vice-versa*. If the guess is exactly right, one stops. If the divisor differs from the quotient, the guess was wrong; one then takes the average of these two numbers; this average is certainly a better approximation to the square root

than either the first divisor or the first quotient. Taking the average thus found as a second approximation, you proceed as before; and this process is repeated as often as necessary, until the quotient differs from the divisor by less than the desired error. The carpenter who used this rule knew all of this, even how to find his error; yet he was actually ashamed of having forgotten the "mathematical" process for square root! It seems to me that we ought to teach this rule in arithmetic, rather than the usual rule, for the students seldom understand the usual rule—that is the reason for it—and they almost invariably forget it quickly. Or is the taboo too strong?

Graphical Approximations. Finally it is interesting to consider the approximation processes associated with graphical work in geometry and in algebra. As an example, it is obvious that the solution of simultaneous equations by the drawing of the corresponding graphs, on larger and larger scale, is actually a pure approximation process. The prejudice against this process is passing away. It is the only really feasible process in many instances, at least for children, as witness the simultaneous quadratics, $x^2+y=7$, $y^2+x=11$. Curiously the taboo against this process conflicts with the fetich for the renowned Horner's process, since these two processes are absolutely identical in their essence.

In geometry, the solution of triangles by means of actual construction of triangles with given parts and actual measurement of the unknown parts is a graphical approximation process. Someone may contend that this is trigonometry; yet a very delicate line must be drawn to exclude these problems from geometry, and if they do have the practical value of trigonometry, should we discriminate *against* them?

Passing over these special examples, let us consider the absolute necessity for graphical figures in order to make precise much which is at present hazy in elementary mathematics. Thus the figure for $y=x^2$, drawn by means of rational values of x, affords the only elementary means of really defining x^2 for irrational values of x. For theoretical purposes the requirement that the curve be continuous is absolutely sufficient to define, for example x^2, which was previously not defined. Again the curve, $x=10y$, drawn for rational values of y defines $y=\log x$ for all values of x if we merely require that the curve be continuous.

Thus the graph, often unjustly sneered at as "only an approximation" is clearly a means (in fact it is the only elementary means) of giving strictly accurate definition to the concepts like x^2 and $\log x$ which occur constantly in elementary mathematics. It is for this reason that the writer has especially emphasized this phase of the graph,—in order that the processes called graphical be recognized as purely mathematical processes, not only justifiable themselves, but, in point of fact, being actually the only elementary means of justifying a large part of the work which is often presumed to have a certain mathematical superiority. This other work—work involving x^2, $\log x$, and $a \times b$ in cases like $\sqrt{2} \times \sqrt{3}$, et cetera, is not only not superior in accuracy and precision from the highest theoretical standpoint, but it is actually dependent for rigor on the concepts called graphical.

This is another instance of fetich and taboo; fetich for a fallacious use of undefined operations like $\sqrt{2} \times \sqrt{3}$; taboo against the eminently justifiable and practical work in graphical representation.

Conclusion. In a famous allegory, Ludwig Fulda has told of a king, who, hearing of the pretended ability of a sorcerer to make a garment which the wise could see, but which was invisible to knaves and fools, and believing that he must pretend to see this fabric in order that he be not esteemed a fool among a court of wise men, threw off his common garments and made public parade in the marvelous costume which the sorceror constructed. Each citizen praised the wonderful beauty of the garments which he could not see, lest he be acknowledged a knave, till a peasant girl, ignorant of the pretended qualities of the garment, exclaimed: "Why, the king has nothing on!"

This allegory applies no more keenly to the foibles of human vanity in alleged belief in popular theories and popular favorites, too often based only upon the fear of condemnation of superior judges, than it does to the curious traditional beliefs and traditional statements of our elementary instruction. Many a proof is hailed as a wonderful invention of the human mind and accepted as genuine, which is in reality nothing but the veriest humbug. Many a homely process is cast aside because it is out of style rather than because it is not serviceable.

Let us beware these false garments which our pride may dictate through our fear of exterior condemnation: the wonderful,

mystical, mysterious theorems on limits and infinite series and incommensurable cases. Let us hold to the modest apparel, which, though lacking the attractive element of mystification to the unitiated, does still possess the fundamental values of utility and certainty: the draughtman's constructions in geometry, the carpenter's rule for square root, the easy trisection of an angle, and in general, each and all of those misjudged and unorthodox processes which are useful illustrations of that mighty principle of approximations which, though often despised, runs through the whole fabric of mathematical learning, and serves to unify and complete what would otherwise be a disjointed mass of uncompleted theories.

SOME COMMENTS ON "A COMMUNICATION."

In "A Communication," page 609, Vol. 8, No. 7, we read, "Say whatever you like, unless a thing can be verified there is no real meaning in it." If so, then unless the word "verified" be very loosely applied there is little of life that has any real meaning. It is well known that one cannot verify the statement, "Through a point not on a straight line there cannot be more than one parallel to that line," so that it would appear that nearly the whole of Euclidean geometry is meaningless. However, before commenting upon the sentence cited, it would be well to inquire the meaning of the terms "verified' and "real"; thus the meaning precedes verification, as will be apparent to anyone who is asked to verify a statement which he does not understand.

As to the next paragraph, no two would likely ever agree as to when an acknowledged difference becomes "practically" *nil*, thus leaving us as far as ever from a settlement of any question. A difference which some might consider negligible might be intolerable to others, as was the case in the calculated and observed positions of Uranus before the discovery of Neptune.

In regard to geometry, if its study be to cultivate the powers of reasoning, a knowledge of the foundations is, for a teacher, in this day absolutely essential; if it be merely to acquaint one with the facts of mensuration, then those who study it are wasting a lot of valuable time.

G. W. Greenwood.

Dunbar, Pa.

Professor C. H. Judd of Yale University has been appointed to the Directorship of the School of Education, University of Chicago. He will begin his residence work July 1st, 1909. Friends of the University of Chicago will be pleased to learn that so eminent a man is to fill the position vacated a few years since by the resignation of Professor John Dewey.

MATHEMATICAL LABORATORIES.

By Gymnasial-Professor Dr. Karl Goldziher,

Budapest.

To bring the abstract into close relation with practical life is an important part of the present efforts for reform in mathematical instruction. It is not simply a matter of developing the utilitarian side of mathematics, but also of solving the problems which have arisen in a thorough investigation of methods of instruction. The purpose is to use to the best advantage the slowly developing intellectual capacity of the pupil; hence the natural starting point is to choose practical problems and give attention equally to "processes of approximation" and "processes of precision." The pedagogical importance of this statement lies in the fact that with deduction there comes into the foreground the gathering and utilizing of practical knowledge itself. If the instruction be grounded on the actual realities of life, the special methods should be developed from the requirements of this wide field so that the pupil in the higher school would learn to comprehend the practical value and real application of abstract ideas.

In the practical solution of this question we are led to see the necessity of such practical exercises as have from the beginning accompanied theoretical instruction. Already in the decade 1890-1900 John Perry in England had succeeded in basing the instruction in mechanics and mathematics in the intermediate technical schools (especially in Finsbury Technical College and in the Royal College of Science, London) on real experimental and laboratory work. This movement has recently gained many supporters in America, especially since Professor E. H. Moore of the University of Chicago in his presidential address before the American Mathematical Society, 1903, emphasized the importance of the laboratory method.[1] Professor Moore urged that the instruction in physics and mathematics be united; in this way could the double character of exact investigation be made prominent; on the one side the experimental knowledge of concrete things, and on the other side the rigorous deductions from the systematic working out of material gathered from experiment. To accomplish this it is evident that laboratories are necessary in which the pupil by his own experiments can secure material

[1] E. H. Moore. On the Foundation of Mathematics. Science, new series XVII, 1903; and Bulletin of the American Mathematical Society, new series IX, 1903.

for instruction in mathematics. In the recently published book of Professor J. W. A. Young, "The Teaching of Mathematics," Longmans, Green & Co., 1907, chapter VI treats in detail of this question.[2] The earlier work of Professor Geo. W. Myers[3] in which detailed instructions for fitting up such a laboratory are given, should be mentioned. In France E. Borel in a lecture before the Conférences du Musée Pédagogique in 1904 showed the importance of uniting the mathematical instruction with practical work.[4] The lecture of Professor Borel gives the general point of view and the administrative details which would have to be considered in establishing a mathematical laboratory.

The one-sidedness of the American experiment lies in the fact that it emphasizes for the most part only the union of physics with mathematics. If the instruction is to touch all the quantitative relations of life the mathematical laboratory must be as far as possible many-sided, and give attention to all the practical applications of mathematics. (It should be noted that Professor Moore includes under physics, astronomy and the more mathematical and physical parts of physiography, and that he would have the physics made thoroughly practical. Moreover, at the present time many of the American teachers who are interested in this movement are trying to connect mathematics with the realities about the pupils and with the general requirements of life. *The translator.*) We mention only the Aufgabensammlung of A. Schülke, Teubner, Part I M. 2.20, Part II M. 2.20, to show that for instruction in algebra there is at hand a whole series of problems from other fields in applied mathematics.[5] Especially in instruction in arithmetic in the lower classes is it of advantage to render less burdensome the study of the pupils by giving them various kinds of practical work. We have at-

[2] The earliest work on this subject seems to be by A. R. Hornbrook, Laboratory Method of Teaching Mathematics; New York, 1905. See further J. W. A. Young, What is the Laboratory Method? School Science and Mathematics, 1903.

[3] Myers, The Laboratory Method in the Secondary School, School Review, 1903. See also the book by Myers, Observational and Experimental Astronomy, Chicago, 1902.

[4] E. Borel, Les exercices pratiques de Mathématiques dans l'enseignement secondaire Conférences du Musée Pedag. 1904 and Revue générale des Sciences, 1904.

[5] As an example of the application of the method to instruction in geometry see the book of P. Martin and O. Schmidt, Raumlehre für Mittelschulen, Bürgerschulen und verwandte Anstalten, 3 Hefte; Berlin, Gerdes und Hödel. In the recent English and American school book literature there has appeared a long series of books which give prominence to the concrete character of the first geometrical instruction and continue this work through mensuration. (Experimental, observational, practical, measuring concrete, inventional, intuitional geometry.) These books support the anti-Euclidian efforts of the Perry school, which recently has found several advocates in France. (See the index on the geometrical instruction of La Revue de l'Enseignement des Sciences.) Of the English and American text-books we mention those of Campbell, Hailmann, Hill, Hornbrook, Lambert, Murray, Spencer (America); Baker and Bourne, Baxandall and Harrison, Budden, Eggar, Hall and Stevens, Harris, Marshall and Tuckey, Morris and Husband, Moore, Morgan, Playne and Fawdry, Stevens (England).

tempted in the following statements to show how in the mathematical laboratory one can make use of the many-sidedness and systematic development of practical exercises. (Several of the following experiments have been made in the government Obergymnasium of the third district in Budapest.)

1. Above all we assert that the practical exercises should be begun in the lower classes and continued throughout the course. In this way the instruction in the lower classes based on concrete knowledge can be built up systematically during the whole course in the domain of the pupils' experience.

2. The mathematical laboratory ought to be independent of the physics and chemistry laboratories, and ought to contain all the models and apparatus necessary for instruction in measuring and weighing. In many cases the pupils can themselves make the required apparatus. The larger units of measure, too, e. g., 1 cubic meter, 1 hectoliter, should be constructed; pupils have worked problems involving these units without having a reasonably clear notion of them. The apparatus should be such that it can be used for accurate measurement. The laboratory should, moreover, contain the apparatus required for simple work in surveying (lower classes), and for more advanced work, especially triangulation (upper classes).

3. In connection with arithmetic there should be work in collecting statistics, and extended computations; the necessary tables should be made out by the pupils themselves. The statistical and related problems provided for geographical, agricultural and economic instruction are especially valuable for the information which they give; they reveal also, for the instruction in arithmetic a fertile and many-sided field which from the methodical side comes into contact with one of the most important processes of experimental work, this we briefly denote by "tabulation." For those who would connect with their instruction in arithmetic, commercial, industrial, economic, financial and insurance problems there should be in the laboratory a collection of blanks, checks, deeds and other business papers, as complete as possible and easily accessible. The exhibition of this material ought to lead to independent use of it by the pupil. Simple exercises in book-keeping may be given to fill out the practical work, since the majority of the pupils never acquire this important subject or acquire it later in life with great difficulty.

4. In the interest of instruction in the upper classes care must be taken that the student secures for himself the material for computation, by measurement and observation in mechanics, physics, chemistry, meteorology, surveying and astronomy. (In the smaller provincial schools or in schools conveniently located, it may be possible to have the official observatory established in the school; astronomical observatories have already been built in several schools.) The systematic revision of the many valuable records of observations would furnish problems for the mathematical laboratory. This material could possibly be secured in other laboratories by the pupils, since the chief purpose might be to work out the results accurately by the methods of applied mathematics.

The following are important problems to which special attention should be given in the mathematical laboratory: the systematic recording and tabulating of the results of observations, the testing and making corrections in instruments which are not accurate, correcting and adjusting the results of observations, the construction of tables which shall be technically correct, and so on. The mathematical laboratory would thus be a workshop for practical mathematics, as it is required to be in Professor Perry's school.[6] The actual use of the modern appliances of applied mathematics, logarithm tables, millimeter paper, calculating machines, graphical calculations, and so on, must be specially emphasized. Theoretical instruction will give only a slight knowledge of these important elements of training. From the university, yes, and from the technical college, too, we hear the complaint that the pupil should not become acquainted with this practical side of mathematics till he is taking advanced work; and the result of this is that often he goes out into life with only a slight knowledge of the practical, underlying principles of mathematics. Students who in the course of their advanced studies have no opportunity to master these modern methods, will be deprived of them through their whole lives if the higher schools have not furnished the necessary introduction.

5. The accurate construction of graphs might be considered an important problem of the mathematical laboratory. The graphical work can be begun in the lower classes and continued in a systematic manner through the entire course in mathematics

[6] In the English and American text-book literature we find a series of books which contain problems for this work. We mention first the text-books, Practical Mathematics by Perry, Castle, Stern and Topham; then the books by Saxelby, Cracknell, Murray, Consterdine and Barnes, Duncan and Macfarlane.

and physics. The larger wall charts, which show quantitative relations (geographical, statistical, economic, and meteorological tables), also the wall charts and tables for instruction in physics and chemistry can be made in the mathematical laboratory by the pupils themselves; in this way the school comes into possession of a collection which is of great value since it has been produced by the independent work of the pupils. The calculations for the graphical work must be done partly in the laboratory and partly in the class room.

6. The preparation of geometrical models is important. This could be commenced in the lowest classes by modeling in clay and wood. In connection with the mathematical laboratory of the gymnasium there should be a drawing room in order that constructions in the higher geometrical instruction might be worked out with accurate drawings.

7. In the teachers' library special attention should be given to the literature of applied mathematics. The systematic collecting of official tabulated statements, the purchase of compilations and hand-books on all topics of applied mathematics and physics, and further the purchase of the most important foreign text-books would be of great value in directing the work in the mathematical laboratory.

(*Translated from Unterrichtsblätter für Mathematik und Naturwissenschaften. 1908. No. 3, by H. E. Cobb.*)

MEETING OF MATHEMATICIANS AT THE UNIVERSITY OF KANSAS.

An event of more than passing interest to Western educators is the meeting at Lawrence, Kansas, on November 28 and 29 of the South Western Section of the American Mathematical Society. The Kansas Association of Mathematics Teachers will hold a meeting in conjunction with the national society and will furnish part of the program. Professors of mathematics from the University of Chicago, the University of Missouri, the University of Nebraska, the University of Oklahoma, and the University of Colorado will be present. Kansas will send a large and representative delegation of her mathematics teachers to the meeting.

Small birds or white mice are sometimes used as indicators of noxious gases, as they are very susceptible to their effects.

Lotherium is the name of a supposedly new element discovered in the decomposition of ytterbium. The experiments were made in Paris.

NEW TERMS IN GEOMETRY.

By G. W. Greenwood,

Dunbar, Pa.

The Committee on Geometry recommends the use of the terms "congruent," "ray," and sect," but as these terms are as yet little used in current texts the majority of teachers are not ready for their immediate adoption. However, the sooner teachers are convinced of the necessity of adopting new terms and of the deficiencies of most current texts in these respects, the sooner better texts will appear and the more cordial will be the welcome afforded them.

A little consideration will show that the term "equal" and its symbol "=" cannot consistently be used to denote both congruence and equivalence, and that the term "line" should not be used indiscriminately for an unlimited straight line, a line limited in one direction such as a side of an angle, and a limited segment of a line such as a side of a triangle. It is one of the paramount objects in geometry to inculcate precision of expression and exactness of thought, to guard against ambiguity and the use of terms at random, and therefore any movement in these directions should receive the support of all progressive teachers; while any objection to such movements would apply equally to the whole of the subject they are now teaching.

A teacher naturally feels that a student, after he has been shown that his reasoning is unsound and can be applied to paradoxes which none would credit, should fully realize the necessity of securing a better demonstration and spare neither time nor effort in remedying the defect. A teacher should himself emulate the spirit he expects the student to show, and which he must show in order to profit by the study of geometry.

Not only are there good reasons for introducing new terms, but it will be found that there should be no objection to doing so. With some at present, however, there seems to be opposition to the introduction of *any* new terms; while the proposed terms are indeed new to beginners, the same is true of most of the other terms in geometry; moreover, it will be apparent that unfamiliarity is no obstacle when we consider the number of strange terms the beginner encounters in every other subject; in geography he learns of Popocatepetl and the Yangtze Kiang; in history he becomes acquainted with Laudonniere and is expected

to remember the storming of Churubusco; in chemistry strange symbols replace all familiar names; the Bible abounds in unusual names and odd expressions; and so for every branch of study. It is not only expected that the student should master all these new terms, but as a rule he succeeds in doing so.

It is a mistake to suppose that the introduction of these new terms will simply burden old and already familiar conceptions with strange names; but even were this the case, we already have ample precedent in geometry as well as in every science for renaming well known objects and properties when precision or an essential shade of meaning is thereby brought out. For example, the student learns that what in the kindergarten he drew and called a "box" is in reality a rectangular parallelopiped (or parallelopipedon), and that its "corners" are trihedral angles; a plane four-sided figure with which he has been familiar from childhood may be designated a polygon, a quadrilateral, a quadrangle, a trapezium, a parallelogram, a rectangle, a rhombus, a square, etc. A teacher would be surprised and skeptical should anyone question the ability of the student to master and properly use these terms; he would rightly oppose the use of a single term —quadrilateral, say—to denote indiscriminately sometimes a trapezium and sometimes a square; yet most of these figures differ only in degree, whereas an unlimited straight line, a line with one end, or "ray," and a line with two ends, or "sect" differ fundamentally, having in common only the undefinable quality of straightness.

Not only is clearness of expression of great pedagogic and cultural value, but it is an invaluable training along the lines of future requirements. In philosophy the utmost pains are taken to secure precise terms; in contracts and agreements words of dual significance must be avoided; the classification of railroad freight is by no means simple, yet a heavy fine and two years' imprisonment hang over one as an inducement to use every precaution in choosing the right term. A few years ago two corporations indulged in a few expensive suits fruitlessly endeavoring to determine whether or not an interurban railway ceased to be a suburban railway under the statutes when it had entered a city.

For teachers to use terms, and permit their students to use terms, with but hazy notions of their significance is to foster habits which tend to unfit them for any important duties.

PRELIMINARY REPORT OF THE COMMITTEE OF THE MATHEMATICS SECTION OF THE CENTRAL ASSOCIATION ON THE UNIFYING OF SECONDARY MATHEMATICS.

(Concluded.)

A Preliminary Outline of Work in Mathematics for Secondary Schools.

1. This outline is to be regarded as strictly tentative; it is a first approximation. It is open to important changes should further consideration reveal the desirability of such alteration. There is presented a list of topics for each year. But no suggestion is made as to the order in which these topics should be taken up.

2. The outline seeks to unify the work in mathematics of the secondary school by presenting arithmetic, algebra, geometry and trigonometry as closely related parts of one subject, mathematics. The mathematical method of thinking about phenomena is carried on in special ways, algebraic and geometric, which are often combined in a given problem. The ability to think in each of these ways must be gained by the pupil. We believe that this ability can be acquired better by a closer coördination than obtains in the usual compartment method. In a more intimate coördination there is a broader field for association of ideas, more opportunity to adapt the work to the growing powers of the pupil and a more essential continuity in mathematical thought.

3. *Time allotment.* The time required per week should be five periods of from forty to fifty minutes each with home work.

It is not advisable to take up geometry, algebra and arithmetic on definite days according to some fixed schedule; rather the basis of division of time should be topical, that is, each topic considered should be considered sufficiently to insure clear impressions.

Some topics are purely algebraic, others purely geometric, while others are a combination of the two; the solution of a quadratic equation is a matter of pure algebra, the investigation of the congruence of triangles is purely geometric while mensuration may be treated as a combination of both methods of thinking. It is important that a clear distinction be made between the study of number and the study of geometric form but more frequent change from one field to the other than is the usual practice is to be desired. Closely related topics in algebra

and geometry should follow each other. We also urge the importance of linking one field to the other by the introduction into each of helpful illustrative material from the other. As an illustration—although the solution of a simple equation is a matter of algebra, a geometrical problem will help to show the usefulness of such solution.

4. *Text-books.* At present there are no texts that can be followed in the class room. Present texts on algebra and geometry can be used, the work being carefully selected, arranged, and supplemented by the teacher. Mimeograph copies of supplementary lessons can be furnished to each pupil. The texts mentioned in this outline will be found to be good sources for material. Eventually proper texts will be evolved, but now each teacher must work out his own courses.

5. *Apparatus.* There should be in the hands of each pupil means of drawing straight lines and circles, of measuring lines and angles; squared paper and a little tracing paper is desirable. (Tissue paper is cheap and good.) The work proposed can be done with the following simple equipment though a more elaborate one can be used to advantage if the necessary funds are at hand.

For the class room:

1. Compasses and rulers for blackboard use.
2. Protractors.
3. A section of board ruled for graphical work.
4. A limited amount of colored crayons.
5. If possible, means for keeping pupils' materials in the class room.
6. Meter sticks.

For the pupils:

1. Some uniform style of paper fair in quality and moderate in cost.
2. Compasses (preferably Eagle Brand).
3. A card to be used as straight edge, protractor, and metric rule. (Or, a ruler combining English and metric measure, and a protractor.)
4. Pen holder and pen.

6. *Distribution of subject matter.* The topics usually considered in courses in algebra and geometry are distributed throughout the whole course on the spiral plan, the more simple and concrete ideas at first, the more complicated, difficult and abstract ideas later. Algebra predominates in the first year, geometry in the second. Arithmetical work is carried on throughout the entire course in conjunction with other topics

wherever it naturally enters. Some use of the trigonometric functions may be made in connection with the triangle.

7. *Reasoning.* In all cases the pupil must not be led faster than he can follow with understanding. He must have some reason for accepting the facts taught; it may be through discovery, intuition, convention, authority, logical deduction or suspended judgment. On this point we commend the reports of the algebra and the geometry committees. As a general scheme we would suggest that in the first year more emphasis be placed on intuitive, inductive methods of getting at truth, leading up to more careful logical thinking in the second year and still more rigorous reasoning in the later years. It must be remembered that the power to reason grows, and the grounds upon which the truth of a statement is accepted change as the pupil grows older. The reason given must appeal to the pupil. "Because it works," is sometimes a sufficient reason.

8. *Methods.* There is a close relationship between the mind and the hand; one learns by handling. Construction of plane and solid geometrical figures, the measuring of real things, the perception of mathematical relations in real phenomena should play an important role, especially in the first two years. It is not always sufficient that a problem about actual things be given to be worked out in an abstract way. But from time to time, actual things should be handled, studied, and measured to give body and substance to the mathematical thinking that is being developed.

OUTLINE.—FIRST YEAR.

A. Algebra: Center the course about the solution of equations.

1. The four fundamental operations upon literal numbers and number expressions.

Omit fractional and general exponents. Use simple fractional and decimal coefficients.

2. Factoring of the type forms:

$$ab+ac,\ a^2-b^2,\ ax^2\pm bx\pm c,\ x^3\pm y^3,$$

and the special forms of multiplication which lead to these products.

3. Simple linear equations and problems, including simple fractional equations.

4. Graphical representation of statistics.

Graphical representation of linear and quadratic functions of one variable.

5. Linear simultaneous equations of two variables.

6. Sufficient work with quadratic surds and imaginaries to enable pupils to solve quadratic equations.

7. Solution of quadratic equations by factoring, completing the square, and formula.

8. Simple work in fractions and fractional equations leading to quadratics.

9. Omit special discussion of H. C. F. and L. C. M.

B. Geometry:

Aim: Systematizing the pupils' notions, instilling clear and correct conceptions of geometric figures and teaching scientific nomenclature and notation; developing manual skill with drawing tools.

Means: Drawing, measuring, and constructing plane and solid figures. Inductive development of certain elementary relations such as:

(a) Mensuration formulæ.

(b) Sum of angles of a polygon.

(c) Pythagorean theorem.

Generally speaking, give the preference to such relations as may be used in problems whose solution will involve the use of the equation.

C. Arithmetic: Make the work in algebra and geometry contribute to the arithmetical equipment of the pupils. Use fractional and decimal coefficients, check solutions by substitution, etc.

In connection with the type forms of multiplication teach short cuts in computation. Also, occasionally give review problems in business arithmetic.

Second Year.

A. Geometry: The portion of plane geometry usually given in the texts.

Omit limits and incommensurable cases.

Eliminate propositions of small value.

Introduce elementary notions of trigonometry in connection with similar triangles.

B. Algebra: Insert exercises the solution of which will involve a knowledge of both geometry and algebra.

Make considerable use of algebraic analysis in exercises in geometry, particularly during the last few months of the course.

In connection with the treatment of ratio and similar figures

teach the chapter on ratio and proportion as given in some good algebra text.

Also, in connection with the theorems on mensuration teach the chapter on radicals, and review square root.

During this year it is not so important that the range of algebraic ideas be extended, as that the portions of algebra covered in the first year be made permanent by continued exercise.

C. Arithmetic: The work of the second year can be made to contribute constantly to arithmetical skill through the use of numerical exercises.

Third and Fourth Years.

This course is divided into two parts which may be given in one year or distributed between the two years.

Part 1. Geometry: Certain theorems of plane geometry that may have been left for treatment here.

Solid Geometry. Omit theorems of small value. Assume Cavalieri's theorem and make use of it in simplifying the treatment of volumes of regular solids.

Algebraic and arithmetical work is naturally involved in mensuration exercises. This is an excellent field for work with radicals and fractions.

Part 2. Algebra: A more orderly and scientific view of the algebra which is usually required for college entrance. Omissions of the first year are to be filled. Among the topics that should receive formal treatment are: Fundamental laws, number system, theory of exponents, theory of logarithms, equivalent equations, a careful study of the equation including quadratic simultaneous equations, inequalities, progressions, and the stating of problems in algebraic language.

Geometry: Exercises in mensuration afford an excellent opportunity for learning how to use fractions, radicals and equations, and also how to prepare formulæ for expeditious arithmetical computation.

Supplement.

In the fourth year there may be given a course in plane trigonometry. (This course in itself makes use of algebraic, geometric and arithmetical ideas.)

H. E. Cobb, Chairman, Lewis Institute, Chicago.
C. E. Comstock, Bradley Polytechnic Institute, Peoria, Ill.
I. S. Condit, Iowa State Normal School, Cedar Falls, Iowa.
W. W. Hart, Shortridge High School, Indianapolis, Ind.
G. C. Shutts, State Normal School, Whitewater, Wis.

EXPERIMENTAL WORK IN BIOLOGY.[1]

BY CYRUS A. KING,

Erasmus High School, Brooklyn.

All will agree, even our worst enemies—the teachers of the classics—that the study of biology gives the pupil both *knowledge* and *mental training*. It matters not how poorly the subject is taught, both these results follow. This, however, is about as definitely as the outsider usually sees the results of our course, for this is, in many instances, what he himself is seeking to give his pupils. To the teacher of biology, this is scarcely an introductory aim. He knows that biology has a definite and special place in the high school course, because if rightly taught it appeals to the pupil in a special way.

Not only must our work give knowledge, but it must, as far as possible, give *first hand* knowledge. The text-book, the great desideratum in his other first-year subjects, is in biology relegated to its proper place in the background and the pupil is required to study the plants and animals themselves. In other words, if our subject justifies itself from our own standpoint, it must derive its chief value from the fact that it is the one subject in his first year that carries the pupil, to a degree, away from his books and makes him study the things themselves. It is necessary for the success of the course that all the biology teachers in the state should be a unit, both theoretically and practically, as to the above conception. For not until we all give our course so as to bring the laboratory side of the work into prominence, shall we meet with the respectful recognition that the subject deserves. The writer is not so unsophisticated as to assume that he is stating any new conception of the biology course. He believes that there is pretty general agreement that the laboratory work should receive emphasis.

Too often, however, we cannot in practice come up to our theoretical ideas of what should be done in the course. Even in our larger schools this is difficult; in the smaller schools of the state, the over-worked teacher, who may be required to teach other subjects beside biology, and, in addition, do enough clerical work for one person, finds he has still less time to give to the prepara-

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[1]Read at the December, 1907, meeting of the New York State Science Teachers' Association.

tion of his laboratory work. On the other hand, if he has a well-equipped laboratory and wants to do the work in the approved way, he is confronted with a whole series of problems on working out a set of studies suited to the needs of his pupils.

To do the laboratory work well, the teacher must have thought through the course and adapted the studies of the various plant and animal forms to the intellectual capacity of the first-year pupils. This course must give the pupils first-hand, definite information about some of the great biological processes that are going on in plants and animals. On the other hand, the teacher must see that the laboratory work does not degenerate into an elementary *nature study* course, nor must it in whole or in part aim to prepare the pupil for the *medical school.*

As a result of all this pressure both from without and within, the teacher is often forced to follow the line of least resistance—to do that which takes the least energy and initiative—to substitute for laboratory work the study of the text-book, charts, and figures.

Whether or not the teacher takes time to do experimental work there is sufficient reason for using it at every available place. It visualizes the question to be considered and thus leads to clearness of conception. The experiment is convincing when successfully carried out. It develops originality and independence in the pupils who must think out, and in part, devise ways and means to do the experiment. It gets a definite series of reactions from the pupils.

The writer has been doing experimental work in his botany classes during the past five years and regards it as an integral part of the work. Before requiring the pupils to do an experiment it is, in most cases, better to discuss it in class. It must be clear that there is some question as to whether a certain organ really does perform a particular work; for example, the question as to whether or not the leaf gives off water vapor. After the question is stated to the class the teacher can then ask for suggestions as to how the pupils could prove whether or not leaves give off water vapor. If the question is too difficult for the pupils to answer at once, assign it for home-work and have them write out additional suggestions for the next day. If the teacher can get the pupils to write a series of statements that show how to prove the point, he has gotten a reaction from them, aroused

interest, and excited their curiosity as to whether their respective theories of the way to prove the problem will work out in actual practice. Finally, as a result of this work, the pupils are better prepared to understand the experiment even though the teacher, in the end, performs it as a demonstration. In fact some of the pupils will test their theories of the more simple experiments before bringing them into class to be discussed and criticised. The teacher should remember, therefore, that one of the most important features of the experimental work is the *discussion* as to how the problem may be solved. It is only in this way that a certain element in each class will actually find out what it is all about. Criticisms and objections to various suggested plans for the experiment will enable these pupils to grasp more clearly the real question to be tested as well as the best means of testing it. It is only after the problem to be tested is clear, and the ways and means of testing it are evident that some of the sluggish, lazy pupils are willing to take the initiative and try the experiment as home work. However, as the teacher carries on the work, he can, by questioning, stir up the indifferent pupils and get from them, too, suggestions as to the way in which new experiments may be done.

It has been the writer's experience that the first year high school pupils soon become good critics of the fairness and accuracy of an experiment. Furthermore, they are, in general, readily taught to be honest in this work. They soon see the value of an honest control experiment and many of them will insist on one before they are willing to accept the evidence as shown by the experiment. Then, too, they are quick to recognize defective experiments, even in our text-books; the practical worthlessness of a conclusion drawn from attempting to grow two seedlings, one of which has been mutilated, has been frequently pointed out to me by my pupils. With a minimum of a dozen of each kind of seedlings the practical results of the experiment are certain to be more accurate and to the pupil will seem fairer.

It is often a stimulus to the experimental home work to have the pupils bring the experiment and the control to school. For this work the pupil should receive official mark because he must be made to feel that he has done, or at least has attempted to do an integral part of the course. If the teacher is in doubt as to the genuineness of these home experiments, one or two detailed

questions will usually decide the matter. As a rule, the pupils can do only the more simple experiments at home. Of these, a full series of observations and notes should be made and, in many cases it is well to ask for illustrations also. Other experiments requiring more apparatus should be set up under the teacher's direction in class and the pupils required to make sketches and notes to show that they understand what the experiment teaches. Finally, some of the experiments are done more satisfactorily during the regular laboratory period. In these, too, the pupil must have a clear notion of the problem and of the reason for each step of the experiment. Otherwise many of the students will passively perform the experiment and not get its real significance.

We have found it a convenience for our pupils to arrange the experimental work into three classes, (a) "laboratory work," (b) "demonstrations," and (c) "home work," with the understanding that the work in the first group is to be done by the individual pupil in the laboratory and is required of all; that the demonstrations are to be performed before the class by the teacher and by pupils with the teacher's help, and that these observations, notes and conclusions form a regular part of the work and are required of all pupils unless marked *optional.* Finally, it is understood that the home work experiments are required unless marked *optional.* The required home work must be written up in neat and logical form.

A simple device that has been of great practical service in the experimental plant work, particularly the home work, has been called for want of a better name a *pocket garden.* It is made in a variety of ways, but a very serviceable one may consist of two negatives that have been cleaned, two pieces of black cloth the same size of the negatives, and several pieces of blotting paper the size of the glass and cloth. After the seeds have been soaked, the pocket garden is made by putting the wet blotters together and the pieces of cloth on each side of them; the seeds, half a dozen or more, are placed on the outside of each piece of cloth and the glasses are put outside the seeds and fastened together at the two ends by means of string or elastic bands.

The pocket garden is now finished, and the student may watch through the glasses all the stages in germination of the various seeds which he has been asked to plant or cares to plant for him-

self. It is necessary to keep the interior moist, but if the garden is generously supplied with blotters it will maintain its moisture for several hours. We have no difficulty whatever in keeping dozens of these gardens in the laboratory indefinitely by putting them on edge into a pan which contains some water. The black cloth is used because the parts of the young seedlings are usually white, and, the root hairs, particularly, come out in sharp contrast on the black background.

These pocket gardens have been used in practically all the experimental work suggested in the state syllabus under Seeds and Seedlings, Roots, and Stems, as well as in additional experiments not suggested by the syllabus.

To use a single illustration, suppose the pupil wants to find out whether or not the roots and stems of germinating seeds have a constant direction of growth with reference to gravity. Two gardens may be used, and while one is kept in the same position, the other is shifted at all sorts of angles to see if there is any corresponding response in the direction of growth of the roots and stems of the half-dozen young plants that are developing on each side of it. India ink marks on the glass may help to follow the migrating movements of these roots and stems.

The syllabus does not suggest experiments under flowers and fruits. It would, however, help to emphasize the function of the flower as a whole, as well as of its stamens and pistils, if the teacher should, as a demonstration, pollinate the flowers of a potted plant and compare the later development of these pistils with others like the begonia, from which pollen has been excluded.

If the pupils have already seen pollen under the microscope, and have observed as a demonstration pollen-tubes that have been germinated artificially, they have an *apperceptive mass* that enables them to understand better the purpose of the pollen, of the stigma, and of fertilization with its bearing on seed production. Since the flower is usually studied chiefly for its taxonomic importance, it will be well to emphasize to the student its *real purpose* as well as the purpose of its parts.

In conclusion, too much emphasis cannot be placed on any work that will emphasize the fact that plants and animals are fundamentally alike—that the same great biological processes are going on in both. For example, the pupil knows that diges-

tion takes place within his own body, that he must be nourished, that he breathes by using up oxygen and giving off carbon dioxide, that there is a circulation of liquids going on within himself, that he is irritable and responds in definite ways to external stimuli and that his body is carrying on other processes, but it has never occurred to him that the same biological activities are going on in the plants about him.

IDEALISM, AN AIM IN BIOLOGY TEACHING.*

By Paul B. Mann,

Morris High School, New York City.

Secondary biology has been afflicted with varying aims and methods, a natural resultant of the youth of the subject, its breadth of horizon, wealth of material, diversified interests and fundamental possibilities. Some time, however, we shall emerge from this condition into a unity of biological purpose. And this purpose will be high and vitalizing, because it will be a reaction against stereotyped and cramping methods. Immature children of the first year of the high school will seldom be taught by a paper teacher of interrogation points, alias the "manual," because the teacher will realize the significance of the opportunities neglected when any substitute is offered for the living contact of teacher and pupil.

In considering the aim in biology teaching, we must remember that the method is often apparent to a casual visitor; the aim, while just as definite, may be obscured by various class room conditions and not be discovered. But its importance cannot be obscured for the aim must largely determine the method. Sometimes the aim accomplished in everyday practice does not accord with the aim of creed, but "it matters not so much where we stand as in what direction we are moving."

I am convinced that many teachers regard the children with the attitude of a photographer. In the laboratory are thirty separate camera boxes carrying sensitized brain-plasm in each. The teacher carefully focuses them on the experiment or demonstration, then draws the black slide of ignorance, develops the results in recitation, and gets a more or less perfect reproduction

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*In substance, a paper read April 3, 1908, before the New York Association of Biology Teachers, New York City.

with fresh examination paper. (*Note: Drill intensifies the image.*) That is, education consists in carefully exposing children to knowledge. I think, however, of education as essentially a process of so feeding, pruning and caring for a plant that it blossoms and ultimately bears fruit.

The first aim is as material as photography itself. In it the child is considered as a recording and transmitting brain and the treatment is essentially that for obtaining a perfect negative. But a child is so much more; is such a complex of mental causes and effects, often thirsting for the new, often led unwillingly to the fountain of knowledge, but always with such spiritual possibilities that our aim becomes paramount.

John E. D. Trask reminds us that "training, no matter how thorough, and knowledge, no matter how wide, never yet made an artist."

If education does not lead a child to realize somewhat his relation to the universe, education has failed. And its failure, then, would be because it did not give him any reasonable excuse for, nor interpretation of, the facts he has learned. "The struggle for existence is so intense in the lives of many as to make this material life intolerable unless relieved by faith in an end to be gained by the struggle."

Laboratory experiments therefore should be so perfectly conducted that the child obtains a true appreciation of the law involved. No experiment is complete without a direct or implied reference to the power governing the action. Experiments should also be conducted in such an orderly atmosphere as will inculcate appreciation of order in general.

Drawings have a moral value. Children from the start ought to be taught to tell with the pencil the truth, the whole of the truth asked for, and nothing but the truth. Slovenly work, careless outlines and inattention to accuracy should disappear not because of the disfavor of the teacher but through the changed attitude of the child toward truth telling. Many children at the start think that telling the truth is entirely an oral performance.

What opportunities the laboratory exercises offer for the gain of independence and self-reliance! Every drawing is always a product of individual work from an individual viewpoint. Good drawings—and sincere efforts will always eventually produce them—are full of stimulating interest, especially when inserted in the notebook as original illustrations of the text.

In considering the essential aim of biology in laboratory experimentation, dissection or drawing, I should like to ask frankly, Is not biology with the rest of the curriculum dangerously near being only an intellectual course, without definite moral aims and ends? To my mind biology, more than any other subject, offers opportunity for correlating subject matter to the great spiritual verities.

The class may be studying seeds in the laboratory and in a crude way have determined the ingredients. The question comes up, could not some great biologist knowing all the ingredients manufacture such seeds artificially? Yes—but like the wonderful wax apples and flowers of the Smithsonian Institution, the factor of life is missing, and our best product would become a mere caricature of the original.

Again, how wonderfully the hidden law operates to check the growth of those same seeds at just the right point of development so that the four hundred pupils in the Morris High School, simultaneously studying the internal structure of the dry bean seed are observing four hundred units *practically identical* even though produced over an area of as many miles and from different plants. When the growing seedling hangs out its green sign telling that its starch factory has begun operations, even the children may clearly see how indebted animals are to the power in plants. The indebtedness is further increased through the process whereby plants can utilize waste carbon dioxide and during the period of this work replenish the atmosphere with oxygen.

When leaves are being studied, we place side by side an example of compound and simple leaves. What is the essential difference? Apparently it is an objective one, of form. But when one considers that chemically the food ingredients must be almost identical, it becomes a question of the selective power, the "invisible intelligence" which changes inorganic liquids and gases in the one case into a palmate veined maple and in the other into the compound leaf of the locust. When you can show your pupils a magnificent king apple grown from a graft on a puny crabapple tree the case is perfect, for here the food of each is obviously the same sap.

And so the botanical applications might be multiplied where the apparently unseen governs the apparently seen, until one had included every page of nature. Take one or two illustrations

from human physiology. The chordæ tendineae of the heart have an exquisite correctness of length where even a slight excess or shortening would be disastrous to their valves. The wonder of it grows, when we realize that in the development of the adult, they have grown ten fold while actually working, and have been changed cell by cell, so that at least every seventh year finds a new set.

Whether someone shall, in the future, be able to give some real explanation of the physics of osmotic action is not necessary to an appreciation of its beautiful efficacy in animal and plant metabolism.

So let the child see how many questions there are unanswerable on a physical or material basis. He will soon see why. Herbert Spencer voiced the expression of all great scientists when he said: "You cannot take up any problem in physics without being quickly led to some metaphysical problem." If a child has been led to regard his body as an organism composed of nothing but transformed food, by means of which his mind finds material expression, then he can readily see how all laboratory work with both animals and plants promptly divides into structure and function. In studying *structure* he is gaining a knowledge simply of the arrangement and characteristics of the *organism*. *Function*, on the other hand, is the organic expression of a power behind the material. It is in the realm of function that our unanswered questions lie.

The fact that we are not able to answer all questions in biology, of itself suggests to the thoughtful mind the operation through the universe of a purpose and plan, emanating from an intelligence the highest we can conceive of. Furthermore, the conception of such a power which we may call, with Spencer, the "First Cause," does not imply that we must in consequence be able clearly to understand the great moral purpose of the universe. We do not understand because we are too much tangled up in materiality. But we are growing and beginning to understand.

Ever since Dr. Beal in 1872, at the dawn of modern biology, defined bioplasm to the world as "living, forming, growing, *self-producing matter*," we have been steeped in materialism. Bioplasm, more commonly called protoplasm, is defined in the Standard dictionary as "*formative*, living matter." But any such statements reason blindly in a circle, trying to find the spiritual

"First Cause" in matter and making gods of the various modes of matter, which at best are the transient symbols of the unseen realities.

If pupils get only the materialistic, that is the common viewpoint, life must later become to them only a series of material causes and effects. They learn to live and expect to live passively in their sensations, out of which in reality they create their world. In the second place such thinking—or lack of true thinking—induces lives devoid of altruism, self-centered because each self is considered an independent creative power. This one effect challenges our thought. Thirdly, all highest and deepest thinking is stifled. Here are no broad and fundamental interpretations of life.

On the other hand, I have found the following results from even small attempts in aiding children to spiritualize their world. *First*—Children gain reverence in the thought of "a power not ourselves which makes for righteousness." *Second*—Some of them become humble searchers after truth and for a knowledge of that power greater than themselves. *Third*—They become more sensitive to the demands of right living. *Fourth*—They are more companionable, teachable, and radiate unselfishness. They are more unselfish, because *Fifth*—They are beginning to realize that they are each an important part of the great cosmic process.

These results may not necessarily appear now. I have never yet been in a class where I was apprehensive that the millennium had actually come. But these results are certain to follow, some in short order and others later.

Now all this may seem unpractical and even visionary transcendentalism. But I maintain that in order to be truly practical we must be idealists. Life is more than bare facts, so called. Lindsay says in the "Spiritual Care of a Child": "Can we lift our children higher than our ideals? Can we lift them at all, if we do not work out our ideals in some practical way?" The teacher who has raised a child to a glimpse of the divinity in a blade of grass has done infinitely more than could ever be done through technical instruction alone. There is no manual for this higher teaching. But the teacher who has the vision can and does bring it to others. Let me quote my text from John Fiske: "The cosmic process exists purely for the sake of moral ends."

BIOLOGY A SINGLE SCIENCE.

By Edgar N. Transeau.

State Normal School, Charleston, Ill.

A year being assumed as the time limit for biological science in the high school, familiarity with the present methods of presenting botany and zoölogy leads one to hope that there is something better in store for the pupil of the future than the present basis for presenting biological ideas.

Assuredly biological topics can be presented to classes using either plants or animals as a basis. But if we study the plans of most of the text-books now in use in either botany or zoölogy, we must be struck by the dearth of biological principles emphasized.

Is not biology very much in the position of the physical geography and geology of a generation ago? There were so many facts to be presented about topographic *forms*, climates, etc., that physical geography was organized purely on a pigeon-hole system, and the one principle in geology worthy of emphasis was the succession of rock formations. The revolution in these subjects came about by the readjustment of the facts on a dynamic basis. Processes are now made the basis of the subdivisions of the subjects. The same facts are presented, but who does not appreciate the marked advantage of the present system over that of the past? In the older presentation the "wealth of facts" determined the method. In the newer, the processes and basic principles of earth science have determined the method and controlled the facts.

Look at the "best sellers" among biological text-books. The one principle that forms the basis for all is the great principle of development of the more complex from the simpler organisms treated more or less adequately from the standpoint of structure alone. To be sure there are *Anhänge* that treat briefly topics in anatomy, physiology, ecology and economics. Is this not exactly comparable with the succession of rock formations of the older geology, with its *Anhänge* of earthquakes, volcanoes, and primitive man—except that "practical" topics in mining and metallurgy were never urged as a necessary part?

If we have in biology no other great principles about which to organize our facts than that of morphological evolution we ought to be satisfied with the "type series," with such side topics as grafting, pruning, mapping of plant societies, seed testing, corn

products, food inspection, dairying, and cattle raising to enable the student to see "the broad areas of contact with his own life." "Wealth of facts" is the real *bete noir* of those who think that everything that is or was a plant or animal must be assimilated into biology.

There are those who assert that our great pedagogical advantage in biology is our ability to "go from the particular to the general" and that all this would be lost were the subject to be organized about the processes and principles. These may find an answer by examining into the history of physiography. The older physical geography went from "the particular to the general." Would anyone venture to assert that this opportunity for inductive thinking has been lost through its reorganization on a dynamic basis? Is there not more chance for inductive training in the laboratory study of the development of stream valleys than in the contemplation of all the *kinds* of undissected and dissected land areas? Is there not more value "practical, pedagogical, and scientific" in the study of volcanoes from the standpoint of *process* than from the standpoint of *"types"?* I have dwelt on these examples from a neighboring science because this subject has been released from the thraldom of "wealth of facts" within our own times.

Biology will surely come as a scientific subject worthy of a place beside physiography, physics, and chemistry, but not until it is organized on a genetic and dynamic basis. This will necessitate a very different point of view from that of a recent text in which forestry, agricultural and horticultural topics, associated with a harmless chapter on cryptogams, are followed by descriptive matter similar in plan to that of a zoölogical-garden handbook, and some human physiology, with appropriate remarks on corsets, suspenders, and cuts of beef. If this is to be the substitute for our present botany and zoölogy, let us resist every effort for a change. It is a question in my mind whether our attitude should be very different toward the biology that will be constructed by "the selection and presentation not so much of the facts as of the great ideas and principles which may be drawn from organized study of a series of plant and animal *forms.*" Is our material of such a nature that we must forever work from the form back to the process? Are there no approaches to the subject except *via* the types?

There is a growing feeling in certain quarters that biology has within its legitimate domain a number of processes and principles

about which plant and animal facts may be grouped in a genetic manner; that variation, heredity, ontogeny, phylogeny, and environmental relations are all susceptible of dynamic treatment; and that on this basis there will result a new biology. Such an advance in point of view cannot of course be brought about in a year, but fortunate will be those who can contribute toward its development.

THE RELATION OF THE SCIENCES IN THE HIGH SCHOOL.

By H. R. Linville,

Jamaica High School, New York.

A history of the origin of secondary schools would be interesting in showing the process of the accumulation of subjects from the lower years of the college course. One can truly say that the high schools have been produced by the continued insistence of the college on the preparation of students in an increasing number of subjects which were college subjects.

The colleges have "passed on" work that they have chosen not to do, until the high school course increasing from one to four years is now so full that sharp competition has developed between the subjects. There was a time in the history of high schools when mathematics, ancient languages and general history just about took up the energy of the pupils, but when the English and other modern languages, ancient, mediaeval and American history and the sciences, came to claim a portion of the pupils' time, competition was inevitable.

Some of the competition, especially that which threatens between the sciences in the high school course of study, is liable to prove extremely wasteful. There are four (or five) sciences which in relation to the competition for being credited by colleges are striving for a place in the third or fourth year of the course. It is probable that nowhere in the country is there a high school curriculum established that has a science course arranged with reference to the logical relation of the sciences. Usually physics and chemistry have the third and fourth years, and biology and physiography take the first and second years or struggle precariously with the better established sciences for a place in the later years.

*Abstract of an address to the Pacific Coast Association of Physics and Chemistry Teachers, Summer Meeting, July 25, 1908.

Teachers of science have it in their power to contribute materially to the saving of educational energy in certain important ways. First, they can demonstrate to the people that the study of the facts and principles of the branches of natural science are necessary to the comprehension of man's environment. If the necessity of knowing the environment could be impressed on the minds of people, every high school would teach the sciences as a matter of course. The second point that might be made by teachers is that there is a *unity* in the sciences which can be brought out by discovering and expressing the logic contained therein. There are fundamental facts and principles upon which the great generalizations are based.

When the thought of teachers is directed toward finding out where their science stands in relation to others, there will be less striving for the "best" years in the high school course. The great usefulness of the sciences in general education will then become apparent.

A LETTER.

Minneapolis, Minn., Nov. 4, 1908.

Editor SCHOOL SCIENCE AND MATHEMATICS:—

As I am a teacher of botany I am particularly pleased with the turn taken in the November number against the teaching of biology as a single science. In October I thought we were going back into the dark ages. The idea of any one thinking that there is not enough of botany of practical interest to fill two semesters! I could use several years to advantage.

Very truly yours,

(MISS) ELOISE BUTLER.

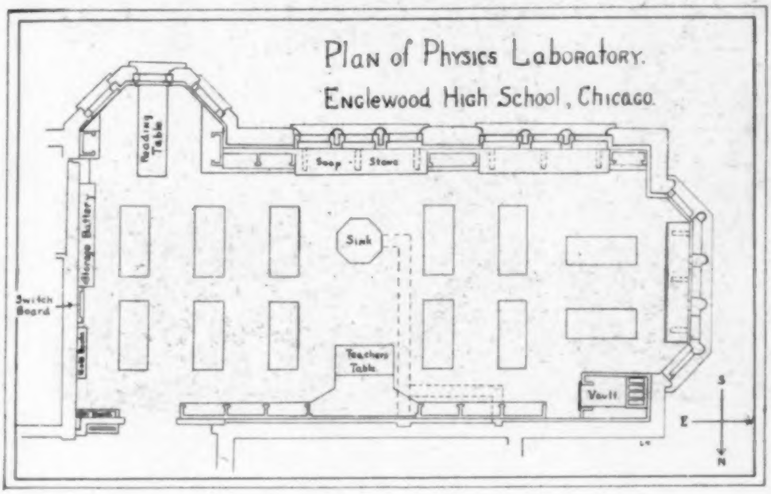
The tin question is a serious one for Russia. At the present moment, with the final stopping of the Pitteiranti tin-smelting works, this industry becomes completely suppressed in Russia, and that just at a time when tin is getting so valuable. The quantity of tin imported into Russia in 1904 was 301,000 poods of the value of 5,730,000 rubles. Therefore it was most desirable that a tin industry should be a feature in Russia. At the Pitkransk deposits such would not be possible, for the tin there is only obtainable along with other useful minerals in very small quantities. Therefore very serious attention should be paid to the tin deposits of the Transbaikal region on the Asian river, which but now have been sufficiently prospected, and in both quantity and quality are hardly surpassed by any known tin deposits.

SCIENCE LABORATORIES AT THE ENGLEWOOD HIGH SCHOOL.

By Willis E. Tower and F. C. Lucas,

The visitor to the Englewood High School, Chicago, is immediately impressed with the convenience and arrangement of the science laboratories. These having been completed within a year, contain some of the latest ideas in laboratory construction.

The chemical laboratory, lecture and other rooms of this department are on the third floor where the fumes may be readily withdrawn without affecting the rest of the building. The physics department is on the second floor, while the botany, zoology, physiographic and commercial geography laboratories are on the first floor.



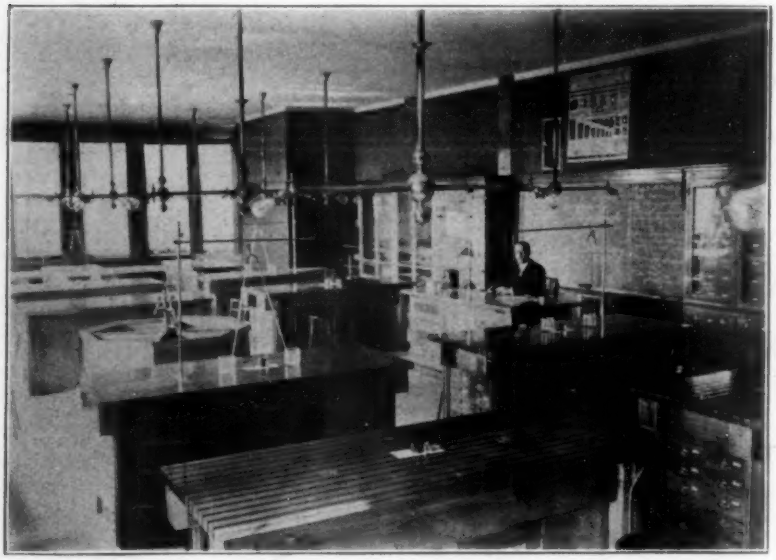
The physics department occupies six rooms, a laboratory 26 by 62 feet, a lecture room 30 feet square and seating fifty, a shop, preparation, photometric and store rooms.

Some features of the laboratory have awakened especial interest and will be given in some detail.

The laboratory tables have built up wood tops with alternate strips of black walnut and hard maple. Four screw plates for 13 and 19 mm. laboratory support rods are set flush with the wood top. Each table has 24 lock drawers for individual pupils and is supplied with four electric and four gas outlets.

The instructor's table is designed for a teacher's desk as well as for demonstration purposes. It stands upon a platform raised six inches and is at the side instead of the end of the room so as to be within easy reach of every pupil.

Behind the table and above the platform is a slate blackboard, on either side of which are cases for apparatus and compartment drawer cases for other material and supplies. The instructor's table is supplied with gas and electric current at several pressures, and with compressed air. The latter is also available at wall tables, for blast lamp work, drying apparatus, and experimental purposes.



PHYSICS LABORATORY.

In one corner of the room is a fireproof vault having a combination lock safe door. This is provided for the safe keeping of valuable apparatus.

In the opposite corner is a bay window containing a reading table. Near this are cases with books for reference and supplementary reading.

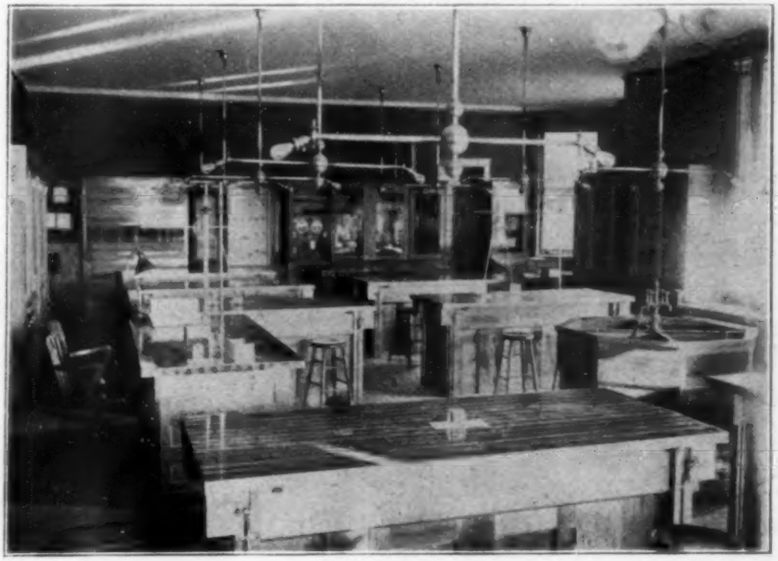
A chloride accumulator storage battery of twelve 5-E cells with facilities for charging and testing is at one end of the room. Next to this is the laboratory switchboard controlling a variety of electric currents for lighting and experimental purposes.

Near the door are keyboard and notebook cases.

The room as a whole is well lighted, facing the south and west. It therefore has direct sunlight available whenever the sun is shining.

From the laboratory a direct connection through the preparation room and shop to the lecture room is provided.

The lecture room has a south exposure making possible the use of direct sunlight at any time. Cases for apparatus extend along one side making it possible to place most of the lecture and demonstration apparatus in the room in which it is to be used.



PHYSICS LABORATORY.

Two opaque screens are used. One at the corner of the front of the room makes possible the use of a stereopticon on the lecture table. The latter has the usual conveniences, including steam and compressed air. This brief description is accompanied by a plan and halftone of the physics laboratory. Descriptions and views of the other laboratories will be given in future issues of SCHOOL SCIENCE AND MATHEMATICS.

The biological laboratories occupy the southwest corner of the first floor. They consist of a laboratory for zoölogy and one for botany, with a private laboratory and storerooms between, where they may be used by both departments.

The zoölogy laboratory is about sixty by forty feet and has light from the west and south. At the east end are placed lecture chairs, thirty-six in number, facing south toward a platform which is in a bay window. On this platform is the customary teacher's desk. There is a small blackboard at the back and a curtain, on spring rollers, in front of the desk, for projection work, the lantern being back of the seats and operated by electricity.

BIOLOGY LABORATORY.

The remainder of the room is devoted to laboratory purposes and for this is provided with tables for thirty-six pupils. These tables are of the pattern adopted by the board of education for its biology laboratories but have black tops. On the north side of these tables is a demonstration table, considerably higher than the laboratory tables, with a small preparation table on one side and a reading table on the other.

The aquaria are at the extreme west end in another bay window and are adapted to keeping the various animals required for the work.

The botany laboratory has the same general plan, but has no recitation seats. A special feature is a large table at the west end, one half being a demonstration table with gas and water connections and the other a series of deep and shallow tanks for the growth of algae and other plants.

PROBLEM DEPARTMENT.

IRA M. DELONG,

University of Colorado, Boulder, Colo.

Readers of the Magazine are invited to send solutions of the problems in this department and also to propose problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to Ira M. DeLong, Boulder, Colo.

Algebra.

118. Find two simple fractions whose denominators are 9 and 5 and whose sum is $2\,{}^{23}/_{45}$.

I. Solution by Wm. B. Borgers, Grand Rapids, Mich.

From the equation of $m/9 + n/5 = (5m + 9n)/45 = {}^{113}/_{45}$, we obtain $5m + 9n = 113$. Therefore a multiple of 5 must be subtracted from 113, leaving a multiple of 9 for remainder. By "casting out the 9's," it is seen that $m = 1$, when $n = 108$ and $n = 12$. This gives the fractions ${}^{1}/_{9}$ and ${}^{12}/_{5}$. Any other value of $5m$ must be 5 plus a multiple of 9, and therefore 5 plus a multiple of 45. Hence the other values are 50 and 90. The three solutions are therefore:

${}^{1}/_{9}$ and ${}^{12}/_{5}$, ${}^{10}/_{9}$ and ${}^{7}/_{5}$, ${}^{19}/_{9}$ and ${}^{2}/_{5}$.

II. Solution by Martin L. Fluckey, Shreve, Ohio.

Let the fractions be $x/5$ and $y/9$, then $9x + 5y = 113$. Since x and y are both integers, neither can be less than 1, whence x cannot be greater than $({}^{113-5})/_{9}$, or 12, and y cannot be greater than $({}^{113-9})/_{5}$, or 20. Suppose $x = 12$, then $y = 1$. But suppose y is greater than 1 by a quantity m. Then $x = [113 - 5\ (1 + m)]/9 = 12 + 5m/9$. Thus, m must be a multiple of 9 in order that x shall be an integer. If $m = 9$, then $y = 10$, $x = 7$; if $m = 2 \times 9$, $y = 19$, $x = 2$. Since y can be no larger, the fractions are ${}^{1}/_{9}$ and ${}^{12}/_{5}$, ${}^{10}/_{9}$ and ${}^{7}/_{5}$, ${}^{19}/_{9}$ and ${}^{2}/_{5}$.

119. *Proposed by A. J. Lewis, A.B., Denver, Colo.*

A and B start to build a brick chimney in the form of the frustum of a pyramid, the lower and upper bases of which are 10 and 2 ft. respectively, the altitude 50 ft., and the flue 20 inches square throughout. They decide that the amount of work in laying is ${}^{2}/_{3}$ of the amount of work in carrying. A begins laying and B carries for him. How high must they go before B begins laying and A carrying if they each want to do an equal amount of work?

I. Solution by G. B. M. Zerr, Ph.D., Philadelphia, Pa.

As nothing is indicated to show where the bricks are placed, it is to be presumed that they are furnished at the height of which they are laid, so that each carries half the bricks while the other lays half. Now 20 inches $= 1\,{}^{2}/_{3}$ ft. Let h = height required, x = side of square at height h, then

$h/3(100 + 10x + x^2) - {}^{25}/_{9}h = (4 + 2x + x^2)\ ({}^{50}-h)/_{3} - {}^{25}/_{9}(50 - h)$

or, $131h + 3hx^2 + 18x = 150x - 325 + 75\,x^2$ .... (1)

Also, $50 : 50 - h = 4 : \frac{1}{2}(x - 2)$ .... (2)

From (1) and (2),

$$48h^3 - 9000h^2 + 546875h - 5421875 = 0,$$

and $\qquad h = 12.21$ ft.

Geometry.

107. *Remark by G. E. Congdon, Hiawatha, Kan.*

It is interesting to note in Problem 107 that the perpendicular bisector of the side BC must bisect the arc of the circumscribed circle, and that the bisector of the angle A also bisects the arc BC and therefore the two lines meet in the circumscribed circle, and outside the triangle if the lines are not coincident. Further, AR + RB = AS + SC considering absolute values only. But since the lines BR and CS are measured in opposite directions, considering their algebraic values the equation is AR + RB = AS — SC.

120. *Proposed by Gertrude L. Roper, Detroit, Mich.*

A man has a 400 ft. lot facing a north and south street. The north and south lines are 1200 and 1500 ft. respectively. The lot runs to an angling street and measures 500 ft. Where shall he build a fence parallel to the 1200, 1500 sides so that his two sons may share equally in the estate?

Solution by W. T. Brewer, Quincy, Ill.

Half the area of the lot is 270,000 sq. ft. Put $100 = a$; then $400 = 4a$, $1200 = 12a$, $1500 = 15a$, $270{,}000 = 27a^2$. Let x = length of fence, $2y$ = distance of fence from the north line of lot.

$(15a + x)(2a - y) = 27a^2$ .... (1)

$(12a + x)y = 27a^2$ .... (2)

Adding these equations, and solving for x,

$x = \frac{1}{2}(24a + 3y)$. Substituting this value in (2) and reducing $y^2 + 16y = 18a^2$; whence $2y = 211.076$ ft.

121. *Proposed by A. M. Harding, Lafayetteville, Ark.*

Given the sum of the three sides of a triangle, the vertical angle, and the perpendicular from the vertical angle to the base. Construct the triangle.

Solution by D. L. Hines, Circleville, Ohio.

Upon the perimeter construct a segment of a circle that will contain an angle equal to 90° plus half the vertical angle. At a distance from the perimeter equal to the perpendicular draw a line parallel to the perimeter. Join one end of its intersections with the arc of the segment to the extremities of the perimeter. Draw the perpendicular bisectors of the last mentioned lines, and join the intersections of these bisectors with the perimeter to the extremity of the parallel already slected, and these two lines, together with that part of the perimeter comprehended between them form the required angle. (See Wentworth's Plane Geometry, Ex. 148, p. 128.)

Applied Mathematics.

122. *Proposed by Walter L. Brown, Fancher, N. Y.*

According to the law of gravity a mass with a given momentum acted upon from a given point by gravity travels in a conic; if it traveled in a semicubical parabola, $y^2 = ax^3$, what would the law of attraction be?

Solution by G. B. M. Zerr, Ph.D., Philadelphia, Pa.

The polar equation is $u = a\cot^2\theta\cos\theta$, where $u = \frac{1}{r}$. Hence $\frac{du}{d\theta} =$ $a - \cot^2\theta(2\csc\theta + \sin\theta)$ and $\frac{d^2u}{d\theta^2} = \frac{6a\cos\theta}{\sin^4\theta} - u$.

Therefore* $F = h^2u^2\left(\frac{d^2u}{d\theta^2} + u\right) = \frac{6ah^2u^2\cos\theta}{\sin^4\theta} = \frac{6ax\sqrt{x^2+y^2}\cdot h^2}{y^4}$.

$\therefore F = \frac{6\sqrt{1+ax}\cdot h^2}{ax^4}$ is the law of attraction in terms of x, h being a constant.

CREDIT FOR SOLUTIONS RECEIVED.

Geometry 89. G. E. Congdon. (1).
Geometry 107. G. E. Congdon. (1).
Algebra 113. Thomas B. Gill, Irvin E. Kline, Calvin M. Woodward. (3).
Trigonometry 116. Gertrude E. Upton. (1).
Algebra 118. T. M. Blakslee, Walter L. Brown, P. S. Berg, Wm. B. Borgers, W. T. Brewer, G. E. Congdon, Martin L. Fluckey, A. M. Harding, D. L. Hines, Irvin E. Kline, Gertrude L. Roper, O. R. Sheldon, Wilfred H. Sherk, Fred J. Taylor, Jessica K. Turner, H. C. Whitaker, G. B. M. Zerr. Also one incorrect solution. (18).
Algebra 119. Walter L. Brown, Martin L. Fluckey (2 solutions), Gertrude L. Roper, H. C. Whitaker, G. B. M. Zerr. (6).
Geometry 120. T. M. Blakslee, Walter L. Brown, P. S. Berg, Wm. B. Borgers, W. T. Brewer, G. E. Congdon, Martin L. Fluckey, A. M. Harding, D. L. Hines, Gertrude L. Roper, O. R. Sheldon, Fred J. Taylor, H. C. Whitaker, G. B. M. Zerr. (14).
Geometry 121. A. M. Allison, Walter L. Brown, G. E. Congdon, A. Grossman, D. L. Hines, H. C. Whitaker, G. B. M. Zerr. Also one incorrect solution. (8).
Applied Mathematics 122. G. B. M. Zerr, Walter L. Brown. (2).
Total number of solutions, 54.

PROBLEMS FOR SOLUTION.

Algebra.

128. *Proposed by J. J. Browne, Golden, Colo.*

Solve

$$bx + cy + az = bc + ca + ab$$
$$cx + ay + bz = bc + ca + ab$$
$$x^2 + y^2 + z^2 = a^2 + b^2 + c^2$$

129. *Proposed by Gertrude L. Roper, Detroit, Mich.*

Explain the following fallacy:

$16 - 36 = -20 = 25 - 45,$
$\therefore 16 - 36 + {}^{81}/_4 = 25 - 45 + {}^{81}/_4$
and therefore $(4 - {}^9/_2)^2 = (5 - {}^9/_2)^2$,
and since $4 - {}^9/_2 = 5 - {}^9/_2$, $4 = 5$.

*See A. G. Webster's, The Dynamics of Particles and Rigid, Elastic and Fluid Bodies, page 39.—*Ed.*

130. A and B traveling the same road were at two towns a miles apart at the same time. On coming together it was found that A, the faster traveler had gone b miles and that the time was equal to the difference of their rates. Find their rates.

Geometry.

131. *Proposed by Jno. A. Hodge, New Albany, Ind.*

Two ladders, 80 and 100 ft. long, have their bases on the opposite sides of a street and lean on the walls of buildings opposite them. If from their point of intersection to the ground it is 10 ft., what is the width of the street?

132. *Proposed by G. E. Congdon, Hiawatha, Kan.*

Given the base, the vertical angle and the radius of the inscribed circle, to construct the triangle.

Applied Mathematics.

133. *Proposed by Irvin E. Kline, Blairstown, N. J.*

A rifle ball is let fall from a balloon 500 ft. high, on a lake 40 ft. deep. How long until it reaches the bottom of the lake?

The following convenient method of section lining a blackboard is used by Superintendent G. E. Wright of the Murray, Iowa, schools: Grind common crayon to a powder and mix it to a thin paste with mucilage and carefully marking our section into 5 cm. distances both above and below and each end (marks corresponding of course) we use a common wrapping cord as a "snap cord" and wetting it in the paste snap it across the marks previously made and let dry. With proper care this ruling will last a long time and can be easily renewed. Any surplus paste can be removed with a damp cloth.

THE LIQUEFYING OF HELIUM.

PROF. ONNES' REMARKABLE ACHIEVEMENT.

On July 10 Prof. H. Kamerlingh Onnes, of Leyden University, and his assistants had the satisfaction of seeing a considerable volume of liquid helium remain for some hours. This conquest over the last and most refractory gas was made known within a day or two, but few details were given until the appearance of the official publication, from which this note is taken.

The day before the successful experiment, July 9, was devoted to the preparation of 75 liters of liquid air, and at 5:45 A. M. on July 10 the work was commenced to obtain the necessary liquid hydrogen. By 1:30 P. M. 20 liters were standing in the special vacuum glasses. Meanwhile the helium and hydrogen circulations were pumped free of air and washed through with their respective gases, and a start was made to cool the liquid-air glass. At 2:30 hydrogen cooled by liquid air was

taken through the hydrogen glass, and by 3 P. M. the temperature was down to —180 deg. C. At 4:20 the helium circulation was started, liquid hydrogen was introduced into its glass, and the pressure lowered until at 5:20 P. M. it reached 6 cm., at which it was kept. Between 5:30 and 6:30 the pressure of helium in the spiral was gradually raised to 100 atmospheres. At 6:35, when the pressure was allowed to fall rapidly to 40 atmospheres, the helium thermometer indicated a temperature below that of the liquid hydrogen; nearly 6 deg. K. was read once. At this time the last reserve of liquid hydrogen was connected, and no liquid helium had been seen. A quicker expansion was allowed, and the temperature fell and constantly returned to the same temperature of less than 5 deg. K. It was as though the thermometer stood in liquid.

Somewhat later, at about 7:30, the surface was seen at the top of the vacuum glass. The liquid having been found under ordinary pressure there was no doubt that the critical pressure was more than 1 atmosphere. The surface was illuminated from below, and had the appearance of a liquid near the critical state in a Cagniard de la Tour tube, cutting the walls like knife-edges, though in this case the diameter was 5 centimeters. There was also a marked contrast between the helium and the hydrogen in the next outer tube. Some of the evaporated helium was now collected and used for a density determination giving 2.01. At 8:30 the pressure on the helium was reduced, and 2.3 centimeters was measured. The pumps, however, can give 2 millimeters, and it is quite possible that as little as 7 millimeters was reached, but no solid could be seen. At 9:40 only a few centimeters of liquid helium remained. Thus liquid helium, starting with an amount exceeding 60 centimeters, had been under observation for more than two hours.

All the evaporated helium was collected into three portions, which gave densities of 2.04, 1.99, and 2.02. As a further test of purity a special comparative spectroscopic investigation was made with known mixtures of hydrogen with helium, and it proved that not more than 0.008 per cent hydrogen was present. This high degree of purity is also confirmed by the easy working of all cocks, which would have been stopped by a very little frozen hydrogen, and also by the condition of the last remaining liquid. The thermometer was also controlled by a measurement of the boiling point of oxygen, which gave 89 deg. K. instead of 90 deg. K.

The properties found are as follows: A boiling point at 4.3 deg. K. on a constant volume helium thermometer with a pressure of 1 atmosphere at about 20 deg. K. Corrected to the absolute scale the best value would appear to be 4.5 deg. K. The triple point, if it exists, is certainly below 1 centimeter, perhaps below 7 millimeters, at which, by corresponding states, the temperature would be about 3 deg. K., and the liquid remains very mobile.

Liquid helium has a density of 0.15. At the boiling point the ratio of vapor to liquid is 1:11, which indicates a critical temperature of not much more than 5 deg. K., and a critical pressure of about 2.3 atmospheres.—*Abstracted from Nature.*

SCIENCE QUESTIONS.

By Franklin T. Jones,

University School, Cleveland, Ohio.

Propose questions for solution or discussion.
Send in solutions of questions asked.
Send examination papers in the sciences.

The following three questions are reprinted from former issues of School Science and Mathematics:

Proposed by E. E. Burns, Medill High School, Chicago, Ill.

A steel spring is wound up. It is then dissolved in acid. What becomes of the energy which the spring is supposed to possess on account of its tension?

Proposed by Charles H. Korns, Bradford, Pa.

A man weighs 150 pounds on a spring at the equator. What would he weigh at the north pole? On the moon? On the sun? What would he weigh at each of these places on a platform balance?

Proposed by J. C. Packard, Brookline, Mass.

How large a square cut from the paper on which this magazine is printed would be required—upon a rough estimate—to produce one calorie of heat when burning in the open air?

There is a train of flat cars one mile long traveling at the rate of one mile a minute. A man stands on the front end and also one on the rear end who has a rifle that will shoot a ball at the rate of one mile a minute. When he shoots at the man on the forward end will the bullet reach him?

Solution by W. L. Malone, Fern Hill, Wash.

If the action of gravity were suspended, the bullet would reach the man, but as the bullet would obey the second law of motion it would certainly fall and be imbedded in the train of cars within one second after it was fired, the time depending upon the height above the car the gun was held when fired.

[The answer published in the June number will be a surprise to many, especially when on reversing the operation, the bullet is made to remain stationary in mid air for a whole minute.]

THE CLASSIFICATION OF CLIMATES.

We call the attention of our readers to a most instructive series of articles by Prof. R. DeC. Ward, on "The classification of climates," published in the Bulletin of the American Geographical Society, for July and August, 1906. After explaining in detail the many classifications that have been suggested by various students, Professor Ward concludes as follows:

"The broad classification of climates into the three general groups of marine, continental, and mountain, with the subordinate divisions of desert, littoral, and monsoon, is convenient for purposes of summarizing the interaction of the climatic elements under the controls of land, water, and altitude. But in any detailed study some scheme of classification is needed in which similar climates in different parts of the world are grouped together, and in which their geographic distribution receives particular consideration. It is obvious from the preceding paragraphs that an almost infinite number of classifications might be proposed; for we may take as the basis of subdivision either the special conditions of one climatic element, as, for example, the same mean annual temperature, or mean annual range of temperature, or the same rainfall, or rainy seasons, or humidity, and so on; or, again, similar conditions of the combination of two or more elements of climate may be made the basis of classification; or we may take a botanical or a zoölogical basis. Of the classifications which have been proposed, special reference is here made to those of Supan, Köppen, and Hult. That of Supan, taken as a whole, gives a rational, simple, and satisfactory scheme of grouping, whose frequent use in climatic descriptions would tend toward system, simplicity, and facility of comparison. It emphasizes the essentials of each climate, and serves to impress these essentials upon the mind by means of the compact, well-considered verbal summary which is given in the case of each province described. Obviously, no classification of climates which is at all complete can approach the simplicity of the ordinary classification of the zones.

"Köppen's admirable scheme of subdividing climates from the botanical point of view is distinctly rather for the use of students of plant geography than of general climatology. The present limits of the different climates in Köppen's map will doubtless need to be changed in several cases, as more detailed botanical studies throw further light on the geographical distribution of different plants, and no rigid delimitation of plant zones is ever satisfactory to everyone. But Köppen's classification has the great merit of recognizing the existing differences of climate between east and west coasts, and between coasts and interiors. The coördination of districts of vegetation and of climate, which this scheme so strikingly emphasizes, is a noteworthy fact in climatology.

"Hult's classification is far too detailed, if all the smaller provinces are taken into account; but if only the larger kingdoms are considered, as in plate II [not reproduced], the scheme is useful. It, however, possesses no advantages over that of Supan, which takes account of more typical characteristics of climate. Ravenstein's hygrothermal types rest upon unsatisfactory data, and regions of very different climatic conditions are grouped together because they happen to have the same mean annual temperature and relative humidity."—*Weather Review.*

THE DEFINITION OF AN ANGLE.

BY WILLIAM F. WHITE, PH.D.

State Normal School, New Paltz, N. Y.

The article in the October number of SCHOOL SCIENCE AND MATHEMATICS, by Professor G. A. Miller, on "Some Questionable Terms and Definitions Used in Elementary Mathematics," I have read and enjoyed. One always reads and enjoys anything from the pen of Professor Miller. In the last paragraph he offers a definition about which I should like to ask some questions. The term defined is "the angle between two straight lines in the plane," and this is the definition proposed: "the amount of rotation which one line may undergo around any one of its points and become parallel to the other line." I want to ask three questions:

1. Should it not read, "any one of its points except that common to the two lines" (the vertex of the angle)? But perhaps this may be dismissed as a quibble.

2. This definition has the merit that it raises no question about angles greater than 2π until the pupil raises it, and when the pupil makes such an inquiry the definition answers it and leads to a broad conception of the term *angle*. But suppose the line be revolved in the wrong way. If the pupil chooses a point in the left arm of the angle and revolves the line in the positive direction, must he not revolve through the supplement of the angle first in mind? If the angle is of 45°, the revolution is, in the case supposed, through 135°, is it not? Should the definition specify the direction of the revolution proposed?

3. Does the definition not imply that whatever one of the points in an arm be chosen, the amount of rotation necessary will be the same, and hence that the corresponding angles made by parallels with a transversal are equal? It seems to me on a first reading that, if we should construct a geometry on this definition of "angle," we should have no further trouble with a parallel-postulate. If on investigation that should prove to be true, we have here a definition with the Euclidian postulate concealed in it.

If one of these questions raises a valid objection, the definition might be classed with those which the author justly punctures. After many definitions have been shown in the article to be useless or incomplete, and one definition is proposed, it would be a pity if that one is likewise open to attack. How much easier is destructive criticism than constructive!

The demand for tungsten ores and products during the first nine months of 1907 was much greater than that of 1906; prices were high, mining and prospecting were both actively carried on, and as a result the output of the United States was increased from a total of 928 short tons of concentrates carrying 60% of tungsten trioxide in 1906 to 1,640 short tons in 1907, while the value rose from \$348,867 in the earlier to \$890,048 in the latter year.

PERSONALS.

Mr. Elmer McClain is now Principal and instructor in Mathematics and Science at the high school. West Newton, Indiana.

Miss Edna McCormack is now teaching Biology in the high school at Indianapolis, Indiana.

Miss Grace Mills is now teaching Science in the high school at Sullivan, Illinois.

Miss Zela Perkins has been appointed to teach Chemistry in the high school at Menominee, Wisconsin.

Miss Helen A. Slaught, a graduate of Vassar College, is teaching Sciences at the high school in Canon City, Colorado.

Mr. James A. Smyser has been appointed teacher of Physiography at the high school, Joliet, Illinois.

Miss Addie A. Spohn is at Woodstock, Illinois, teaching Mathematics in the high school.

Miss Hildur C. Westlund is now teaching Mathematics in the high school at Harvard, Illinois.

Mr. H. C. Wright has gone to the Clyde Township High School, Berwyn, Illinois, to teach Mathematics and History.

Mr. Hamilton C. Badger has been appointed teacher of the Sciences at the high school, Pocatello, Idaho.

Mr. Clyde M. Bauer is teacher of Physiography at the Township High School, Centralia, Illinois.

Mr. Adolph Bernard, Ph.D., has been re-elected for the third year as teacher of Science at the high school, Green Bay, Wisconsin.

Mr. H. E. Bennett is now teaching Mathematics at the high school, Muskegon, Illinois.

Mr. Walter Hart, formerly of the University High School, Chicago, is now head of the department of Mathematics in the Shortridge High School, Indianapolis, Ind.

Mr. Jesse Brenneman has gone to the high school at Decatur, Illinois, as teacher of Physiography.

Mr. William Bryan is at Palo Alto, California, teaching Chemistry in the high school.

Mr. W. D. Buchanan is teaching Sciences at the Northern Arizona Normal, Flagstaff, Arizona.

Miss Florence A. Cutright is principal of the high school at Fairfield Illinois, and also teaches Physiology.

Miss Mary L. Dement was appointed to teach Sciences at the new Trier High School, Kenilworth, Illinois.

Mr. Homer G. Derr has gone to the high school at Butte, Montana, as teacher of Physics.

Mr. H. R. Kingston is at the Shortridge High School, Indianapolis, Indiana as instructor in Mathematics.

Mr. Louis Knox is now teaching Chemistry at the South Carolina Military Academy, Charleston.

Mr. Bohumil Kral is now teaching Mathematics at the high school, Sheboygan, Wisconsin.

Mr. H. F. McNeish, for some years instructor in mathematics in the University of Chicago High School, has accepted a position as instructor of mathematics in Princeton University.

Dr. L. P. Barclay, formerly representing Bausch & Lomb Optical Co., died on September 1st at the Loomis Sanatorium, Liberty, N. Y.

Mr. Edward L. Bailey has resumed editorial management of the *Mississippi School Journal*, and the address is now Jackson, Miss.

James F. Millis, formerly of the Shortridge High School, Indianapolis, who has been the past year attending the Teachers College, New York, becomes head of the Mathematics Department in the Francis W. Parker School, Chicago.

H. S. Robertson of the Collegiate Institute, Stratford, Ontario, who the past year has been studying at Columbus University, takes charge of the Mathematics in the Provincial Normal School, Stratford.

J. C. Packard, Instructor in Physics in the Brookline, Mass., is devoting this year to study in Europe.

Arrangements have been perfected whereby the L. E. Knott Apparatus Co. and the Arthur W. Hall Scientific Company of Boston will combine. Mr. Arthur W. Hall is to be actively connected with the new management. Mr. E. Cate, after more than a year's absence, partly abroad, resumes connection. Mr. L. E. Knott retires.

ARTICLES IN CURRENT MAGAZINES.

Review of Reviews for October: "Tolstoy at Eighty," illustrated; "'Welfare Work' on American Railroads," William Menkel.

Photo-Era for October: "William Norrie: His Art and Methods," William Findlay; "The Degradation of the Motion Picture," C. H. Claudy; "Simple Methods of Manipulating Negatives," Walter Winchester, M.D.; "Calculating Exposure with a Telephoto Lens," Phil M. Riley.

Mining Science for October 1: "The Nitrate Deposits and Industry in Chile," L. Lema. For October 8: "Placer Mining with Dredges as Practiced in California," Al. H. Martin.

Scientific American Supplement for October 3: "The Movement of Plants," Francis Darwin; "Armor-Bearing Animals." For October 10: "Our American Flycatchers," B. S. Bowdish; "The Movement of Plants," Francis Darwin; "The Flaming Arc Lamp," Alfred A. Wohlauer. For October 17: "Pneumatic Caissons," T. Hennard Thomson; "The Hedjaz Railroad;" "The Seasonsal Activities of Plants," D. T. MacDougal; "Some Astronomical Fallacies," J. E. Gore. For October 24: "Photography in World Progress," W. I. Scandlin; "The Absolute Zero of Temperature," Francis Hyndman.

Popular Science Monthly for October: "The Spoliation of the Falls of Niagara," Dr. J. W. Spencer; "The Industries of Niagara Falls," Raymond H. Arnot; "The Classification of Mathematics," Professor G. A. Miller; "Academic Aspects of Administration," Professor Joseph Jastrow; "Something New in 'Freewill,'" George Stuart Fullerton; "The Specialist Blight on American Education," James P. Munroe; "The Laws of Social Attraction," Professor Simon N. Patten; "The Passing of the Sturgeon: A Case of the Unparalleled Extermination of a Species," Dr. Walter Sheldon Tower; "Foreign Associates of National Societies," Professor E. C. Pickering. For November: "Deductions from the Records of Running in the Last Olympiad," A. E. Kennelly; "Monte Alban and Mitla as the Tourist sees Them," Charles Joseph Chamberlain; "The Rotation of Crops," Samuel Fraser; "The Public School Teacher in a Democracy," Henry R. Linville; "Celibate Education To-Day," E. S.; "The Inadequacy of Speech," Chas. W. Super; "Zoölogy," Henry E. Crampton; "Experiments with Langley's Aerodrome," S. P. Langley.

Physical Review for October: "New Groups of Residual Rays in the Long-Wave Spectrum," E. F. Nichols and W. S. Day; "Some Electrical Properties of Silicon. IV. The Electromotive Force of Cells in which Silicon Forms One Electrode," Frances G. Wick; "A Convenient Form of Galvanometer with Magnetic Shielding," E. F. Nichols and S. R. Williams; "Capacity and Current Density Effects in the Argon and Hydrogen Spectra," Charles Sheard; "Effect of Absorbed Hydrogen and of Other Gases on the Photo-Electric Activity of Metals," V. L. Chrisler; "Optical Properties of Collodion and Celluloid," A. Trowbridge; "A Sine-Wave Electrical Oscillator of the Organ Pipe Type," Frederick K. Vreeland; "On the Range and Total Ionization of the *a* Particle," S. J. Allen; "On the Conductance and Fluidity of Fused Salts," H. M. Goodwin and H. T. Kalmus; "Note on the Reproducibility of Cadmium Cells," P. I. Wold.

Bird Lore for September-October: "A Raven's Nest," Francis H. Allen; "Hummingbird Eccentricities," Mary P. Allen; "A Mocking Bird's June," Albert V. Goodpasture; "The Migration of Flycatchers," Professor W. W. Cooke.

The *Plant World* for September: "The Course of the Vegetative Seasons in Southern Arizona," D. T. MacDougal, illustrated; "Methods of Vegetative Reproduction in Guayule and Marrola," Francis E. Lloyd; "The Western Edge of the Colorado Desert," V. M. Spaulding.

Biological Bulletin for October: "A Significant Case of Hermaphroditism in Fish," H. H. Newman; "The Homing of the Mud-douber," C. H. Turner; "Extrasion of the Winter Egg Capsule in Planaria Simplissisima," F. E. Chidester; "Lysaraphus, a Permian Urodele," S. W. Williston.

Economic Geology for August-September: "Occurrence and Genesis of the Iron Ores of Shasta County, California," Basil Prescott; "Geology of Illinois Petroleum Fields," H. F. Bain; "The Ore Deposits at Mineral, Idaho." "Cement Materials of Western Virginia," R. S. Bassler; "A New Discovery of Pendotite in Arkansas," A. H. Purdue.

Journal of Geology for September-October: "The Red Beds of Northern Colorado," Junius Henderson; "Glacial Drift Under the St. Louis Loess," J. A. Drushel; "The Japanese Volcano Aso and its Large Caldera," Robert Anderson; "Marginal Glacial Drainage Features in the Finger Lake Region," John L. Rich; "Relation of Wind to Topography of Contal Drift Sands," Peter Olsson-Seffer; "An Interglacial Fauna Found in Cayuga Valley and its Relation to the Pleistocene of Toronto," C. J. Maury.

Terrestrial Magnetism for September: "On the Distribution of Magnetism over the Earth's Surface," P. T. Passolsky; "Report of the Atmospheric Electricity Observations Made on the Magnetic Survey Yacht, Galilee," P. H. Dike.

Astrophysical Journal for October: "Wave-length Measurements for the Establishment of a System of Spectroscopic Standards," C. Fabey and H. Bursson; "A Redetermination of the Wave-lengths of Standard Iron Lines," A. H. Pfund; "Notes on the Determination of the Orbits of Spectroscopic Binaries," H. C. Plummer; "On a New Law of Series Spectra," W. Ritz; "The Pasadena Laboratory of the Mount Wilson Solar Observatory," George E. Hale.

GIFTS.

EIGHTH ANNUAL MEETING OF CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS, ENGLEWOOD HIGH SCHOOL, CHICAGO, NOV. 26-28.

General Meeting.

Address: Modern Chemistry and Industry.

ROBERT KENNEDY DUNCAN, Professor of Industrial Chemistry, The University of Kansas.

Address: Problems in Secondary School Agriculture.

D. O. BARTO, College of Agriculture, University of Illinois.

W. H. ELSON, Superintendent of Schools, Cleveland, Ohio.

Biology.

Field Work on Trees.

I. N. MITCHELL, State Normal School, Milwaukee, Wis.

Field Work on Birds for City Schools.

LYNDS JONES, Associate Professor of Zoölogy, Oberlin College, Oberlin, Ohio.

Field Work on Common Weeds.

HENRY C. COWLES, Professor of Botany, University of Chicago, Chicago, Ill.

Field Work on Insects.

JUSTUS W. FOLSOM, Associate in Entomology, University of Illinois, Urbana, Ill.

Field Work on Fishes.

T. L. HANKINSON, State Normal School, Charleston, Ill.

Report of the Committee on Formulation of Principles.

Chemistry.

How May Instruction in Elementary Chemistry be Made more Efficient?

E. B. HUTCHINS, JR., Professor of Chemistry, Carroll College, Waukesha, Wis.

Difficulties to be Met in Secondary School Chemistry.

J. L. WELTER, High School, Wilkesbarre, Pa.

Preliminary Report on Fundamentals in Secondary School Chemistry.

Round Table (A) Chemical Theory in the Secondary School Course, What, How and When Presented?

(B) The Practical versus the Technical in High School Chemistry.

(C) In a Five-Year High School Course, what Shall be Given as Second-Year Chemistry?

Earth Science.

Fundamental Topics in a Physiographic Study of the Land.

ROLLIN D. SALISBURY, Professor of Geographic Geology, University of Chicago.

Facts and Principles of Meteorology that are Essential to Physiography.

MARK JEFFERSON, Professor of Geography, State Normal College, Ypsilanti, Mich.

Methods of Teaching by which the Fundamental parts of Physiography may be Emphasized.

RALPH E. BLOUNT, Robert Waller High School, Chicago.

GEORGE A. BARKER, Illinois State Normal University, Normal, Ill.

The Practical Value of the Study of Geology.

U. S. GRANT, Professor of Geology, Northwestern University, Evanston, Ill.

Physics.

Address—The Coördination of High School and College Physics.

R. A. MILLIKAN, Professor of Physics, University of Chicago.

A. A. UPHAM, State Normal School, Whitewater, Wis.

JOHN F. WOODHULL, Professor of Natural Science, Teachers College, New York.

Experimental Lecture—Elementary Dynamics with some Simple Demonstrations.

HENRY CREW, Professor of Physics, Northwestern University.

SYMPOSIUM.

What are the Fundamentals?

1. In Mechanics.

G. M. WILCOX, Professor of Physics, Armour Institute, Chicago.

B. L. STEELE, Shortridge High School, Indianapolis.

2. In Sound.

DAYTON C. MILLER, Professor of Physics, Case School of Applied Science.

3. In Heat.

KARL GUTHE, Professor of Physics, State University of Iowa.

4. In Electricity.

JOHN F. WOODHULL, Professor of Natural Science, Teachers' College.

5. In Light.

GEO. R. TWISS, High School Inspector, Columbus, Ohio.

Mathematics.

Presentation of the report and discussion.

HERBERT E. COBB, Lewis Institute, Chicago, *Chairman of the Committee.*

6. The Report of the Committee on Geometry.

G. W. GREENWOOD. *Chairman of the Committee.*

A Second Report of the Committee on Algebra in the Secondary Schools.

Presentation of the report and discussion.

CHAS. AMMERMAN, McKinley High School, St. Louis, Mo., *Chairman of the Committee.*

GEORGE BRUCE HALSTED, Greeley, Colorado.
W. H. WILLIAMS, State Normal School, Platteville, Wis.
LOUIS P. JOCELYN, Ann Arbor (Mich.) High School.

Write the Secretary, Mr. Willis E. Tower, Englewood High School, Chicago, for other information.

THE AMERICAN FEDERATION OF TEACHERS OF THE MATHEMATICAL AND NATURAL SCIENCES.

The annual meeting of the Federation will be held at Johns Hopkins University, Baltimore, on December 28-29, 1908. There will be two sessions; one a business meeting of the Council, at which reports will be presented from the executive committee and the various local associations, officers for the coming year elected, committees appointed, etc.; the other a joint session with Section L of the American Association for the Advancement of Science, at which the problems of science teaching will be discussed by the following speakers: R. S. Woodward, President of the Carnegie Foundation; Ira Remsen, President of Johns Hopkins University; G. F. Stradling, Philadelphia (Physics); Wm. T. Campbell, Boston (Mathematics); N. M. Fennemann, Cincinnati (Geography); J. M. Coulter, Chicago (Botany). The first will be a meeting of the delegates of the federated associations, and the second a meeting open to all. The exact times and places of the meetings and the full programs will be announced later.

BOOKS RECEIVED.

Electricity, Sound, and Light, by Robert A. Millikan, University of Chicago, and John Mills, Western Reserve University. 8vo. Cloth. 389 pages, illustrated. Mailing price, $2.15. Ginn & Co., Boston.

Practical Exercises in Physical Geography, with atlas, by W. M. Davis, Harvard University. 12mo. Cloth. 148 pages, illustrated. Mailing price, 50 cents. Ginn & Co., Boston.

The American College, a criticism by Abraham Flexner. 12mo. 237 pages. $1.07 postpaid. The Century Company, New York.

The Pope and the Comet, William F. Rigge, Omaha, Nebraska.

A Text-Book of Inorganic Chemistry by Dr. A. F. Halleman. Issued in English in coöperation with H. C. Cooper, 1908. 3d English Edition. 8vo, viii+502 pages, 81 figures. Cloth, $2.50. New York: John Wiley & Sons.

Economic Zoölogy, an Introductory Text-Book in Zoölogy by Herbert Osborn. 1908. Pp. 490. New York: Macmillan Co. Price, $2.00 net.

Progressive Problems in Physics by Fred R. Miller. 1908. Boston: D. C. Heath & Co. Pp. 218. Price, 60 cents.

Laboratory Arts, A Teacher's Handbook, dealing with materials and tools used in the construction, adjustment and repair of scientific instruments by Geo. H. Woollatt. London: Longmans, Green & Co. Pp. 192. 1908.

Differential and Integral Calculus by Daniel A. Murray. 1908. Pp. xviii+491. 1908. New York: Longmans, Green & Co. Price, $2.00.

Some Living Things, Primary Lessons in Physiology, by Ella B. Halleck and C. B. Gilbert. 1908. Pp. 214. New York: A. S. Barnes & Co. Price, postpaid, 45 cents.

Principles of Physiology and Hygiene by G. W. Fitz, M. D. 1908. Pp. 357. New York: Henry Holt & Co. Price, $1.12.

The Parallel Course Drawing Books, C. S. and A. G. Hammock. Books 1-4. 1908. Boston: D. C. Heath & Co.

Applied Arts Drawing Books by Wilhelmina Seegmiller. Books 3-8. 1908. Chicago: Atkinson, Mentzer, & Grover.

Nature Study Made Easy by E. B. Shallow, and Winifred T. Cullen. 1908. Pp. 136. New York: The Macmillan Co. Price, 40 cents net.

A Secondary Arithmetic, Commercial and Industrial, by G. J. C. Stone and J. F. Millis. Pp. 221. 1908. Boston: Benj. H. Sanborn & Co. Price, 75 cents.

BOOK REVIEWS.

A Laboratory Guide for Students in Physical Sciences, by H. Schapper, professor of physics, University of Arkansas. 12 mo, v+61 pages. Cloth, $1.00. John Wiley and Sons, New York.

This is a splendid little book and ought to fill the long-felt want of the teacher of secondary school physics in helping him to instill into the minds of his pupils habits of accuracy, the graphical representation of results, and their interpretation. The book might well be used as a supplement to the physical laboratory manual. All Boards of Education should authorize the purchase of several copies of this book for use in the physics laboratories under their control. C. H. S.

Magic Squares and Cubes, W. S. Andrews, with chapters by Paul Carus, L. S. Frierson, and C. A. Browne, Jr. Pp. 199. $1.50. The Open Court Publishing Co., Chicago. 1908.

While magic squares may be considered simply as mathematical curiosities, they are constructed on fixed laws which are said to be algebraical rather than arithmetical and closely connected with infinitesimal calculus and the theory of groups. In the preface, Dr. Carus says: "There is no science that teaches the harmonies of nature more clearly than mathematics, and the magic squares are like a magic mirror which reflects a ray of the symmetry of the divine norm immanent in all things, in the immeasurable immensity of the cosmos not less than in the mysterious depths of the human mind." This book is written for the schoolboy as well as for the mathematician, and the boy who is interested in mathematics will find rules for making magic squares and cubes which are easily understood and applied. The titles of the chapters, Magic Squares, Magic Cubes, The Franklin Squares, Reflections on Magic Squares, A Mathematical Study of Magic Squares, Magic Squares and Pythagorean Numbers, Some Curious Magic Squares, indicate the scope and method of the book. Like all by which Magic Squares May be Classified, The Mathematical Value of Magic Squares, indicate the scope and methods of the book. Like all the books of the Open Court Mathematical Series it is printed and bound in attractive form. H. E. C.

General Physics, an Elementary Text-Book for Colleges, by Henry Crew, Professor of Physics in Northwestern University. Cloth, 8 vo, xi+522 pages, 404 figures, $2.75 net; by mail, $2.94. The Macmillan Company, 64 Fifth Avenue, New York.

It is fortunate for first year college men and secondary school instructors of physics that this prince of physics teachers concluded to "transfer a course of lectures from flexible manuscript to rigid type." This book is a modern Ganot to the classes of people just mentioned. It is a book which can be read as well as studied with interest. One is sure of the statements made, as they come from one who is an authority on the subject.

The object of the author is "not merely, or even mainly, to impart information, but to set before the student a large and compact body of truth obtained by a method which shall remain for him throughout life a pattern and norm of clear and correct thinking."

There are 425 well-selected problems taken from everyday experience; they are therefore practical, the answers not being given except in a few instances. No higher mathematics than trigonometry is used in the book.

The mechanical part of the book is well executed. It has an extra sewed flexible back which causes it to lie open easily. The body of the book is set in clear ten-point type. It is a text which every secondary school instructor should have in his own library as well as in the general physics library of his school. C. H. S.

An Introduction to the Study of Electrical Engineering, by Henry H. Norris, Professor of Electrical Engineering, Sibley College, Cornell University. 8vo. v+404 pages, 179 figures. Cloth, $2.50 net. John Wiley & Sons, New York.

During the last fifteen years many books have been written treating of this subject. None of them, however, present this science in a more clear and forcible manner. The style and order of treatment is splendid. Any person with a knowledge of electricity no greater than that received in a good secondary school course in physics will be able to understand and appreciate this work. The author keeps in mind the fact that one to be a first class electrical engineer must also be a good mechanical engineer. In modern practice these two professions are inseparably linked.

The book is divided into thirteen chapters, each filled with useful information.

Chapter I is devoted to the historical development, beginning with the period of mystery and closing with the period of commercial development. In discussing the subject the author begins at the very fundamentals and proceeds in sequence reserving until the last the treatment of that which is perhaps most difficult to comprehend, the measurement of currents and power in their various phases. Materials of electrical engineering, electric and magnetic circuits are clearly discussed. Construction and operation of electric generators, transformers and their application receive much attention. Construction

and operation of power stations, electric motors, electric lighting and heating receive their share of space. A chapter on the transmission of intelligence is given. A complete index is added. This is a book that all physics teachers and electrical engineers should own.

The mechanical work on the book is of a very high order. The type is large and clear, matter is not crowded, the cuts being exceptionally well selected, executed and printed. C. H. S.

Arithmetic. Books I, II, III, by George W. Myers, Professor of the Teaching of Mathematics and Astronomy, College of Education, The University of Chicago. Pp. 209, 256, 308. Scott, Foresman and Co. 1908.

Those who know Dr. Myers through his addresses and articles in educational journals will learn on looking through these books that he can put his ideas of theory and practice into workable shape in text-books. Arithmetic as presented here includes form-study which gradually develops into the rudiments of geometry in the higher grades; it also includes the first notions of algebra under the form of general arithmetic. This work is so completely unified with the central core, arithmetic, that the books well deserve the name Elementary-school Mathematics. Book I is for the third and fourth grades.

A few of the topics are: Need of measuring, estimating, and measuring lengths and surfaces, fours, drawing to scale, fives, money and time, sixes, boxmaking, and so on. Problems having to do with gardens, recipes for cake and candy making, furnishing a home and a doll-house, buying groceries, etc., furnish the material for number work. Book II is for the fifth and sixth grades. Measuring, scale drawing, uses of the triangle, problems in values—ratios, addition, subtraction, multiplication, division, the equation, fractions, percentage, interest, are a few of the topics. The first part of Book II is predominantly, not exclusively, spiral in treatment; the second part is predominantly, not exclusively, topical in treatment. The author recognizes that in the intermediate grades the pupil's mental attitude is transitional and has endeavored to meet the difficulty. Book III, for the seventh and eighth grades, is a complete arithmetic in which all the essentials are included. The elements of algebra and geometry are closely correlated with the arithmetic so that those who never enter the high school may have a slight working knowledge of these more powerful instruments; and those who continue the subjects will have the best kind of preparation for the more formal study. Teachers of algebra and geometry should read this book for hints in correlating the various branches of mathematics. It is to be hoped that this arithmetic will be widely adopted; for when teachers get hold of its spirit and method there will be good teaching, and children will in their arithmetic receive training in judgment, concentration of thought, and clear thinking through work which is of interest to them. The mechanical construction of the books is excellent. The type is large and clear, the pages are open, and there is an abundance of diagrams and drawings. H. E. C.

The Common Sense of the Milk Question, by John Spargo. Published by the Macmillan Company. Pages, 351 + xiv; 26 photographs. Price, $1.50.

In "The Common Sense of the Milk Question" we have an attempt to make the problem of milk supply so graphic that it will appeal to the reader who is not familiar with its bacteriological, medical, or hygienic aspects. The sociological trend of the discussion is indicated by such chapter headings as, "The Rise in the Value of Babies," "When the Mothers Fail," "Filth as Infants' Food," and "Outlines of a Policy of Reform." Indeed the entire book is rather a work upon the sociological aspects of the milk question than strictly upon its hygiene.

Much of the book is theoretical. The author argues that modern life with its many interests serves to give so great over stimulation to the mind of woman that such animal functions as lactation are deteriorating, that as a result we are becoming increasingly dependent upon artificial milk for children, hence the increasing importance of attention to the nature of the supply of this milk. Whether this and other sociological explanations of the loss or deterioration of physiological functions are true, the book will do a good service in helping to focus public attention upon the fact that in our present ways of living we need a large supply of artificial milk, and that this supply should be freed from many impurities that it now holds.

Ample presentation is made of the many cases of ignorant and intelligent criminal negligence in milk pollution. The failure to introduce proper standards, or the failure properly to enforce standards is cited in case of such cities as Boston, Cambridge, and Brocton. The author states that the people in such cities feel fairly secure but really would be more secure if they had no standards of purity, since then they would be on guard against evils to which they are now constantly exposed. Of course such discarding of standards could not safely be done. The city of New York gets its milk supply of 1,600,000 quarts daily from over 35,000 farms, shipped through 700 creameries, and it is obvious that high and rigorous standards must be established and enforced if the health of the people is to receive anything like the proper protection.

The "Outlines of a Policy of Reform" is full of interesting suggestion. The United States meat inspection will doubtless remove some of the difficulties presented by Mr. Spargo. It may be true that, as he says, "As a recent result of this policy, many farmers, men upon whom we must largely depend if we are to eradicate the disease (tuberculosis), are in a conspiracy to prevent the detection of infected cattle." It is doubtless true that the government has not made adequate return for all the cattle destroyed, but certainly animal and meat inspection is giving the public better and better protection against infected meat.

A twenty-two page bibliography adds to the value of the book.

O. W. C.

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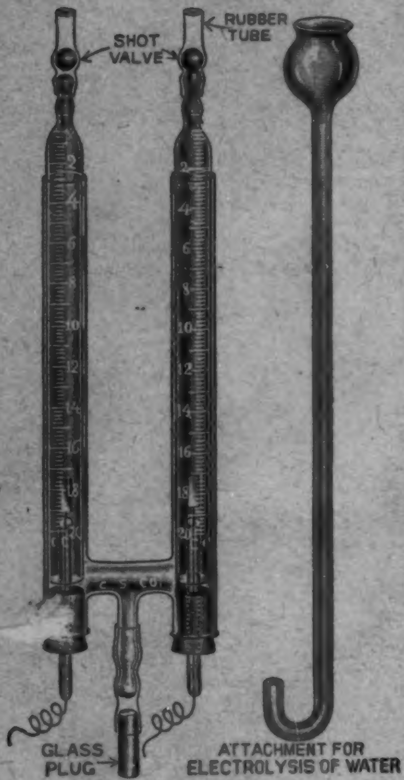

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